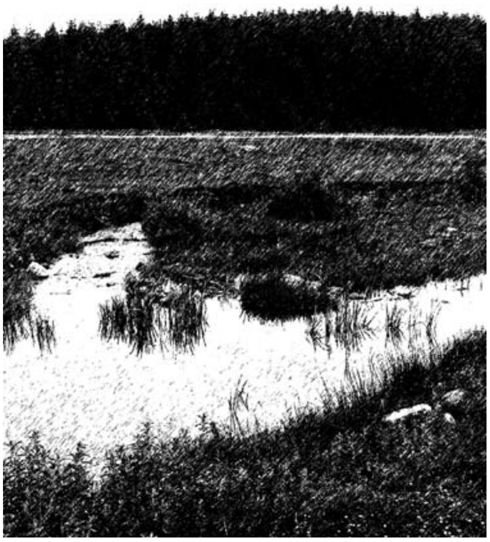
International Scientific Conference
In occasion of 60 year of operation of Institute of Forestry, Belgrade, Serbia

SUSTAINABLE USE OF FOREST ECOSYSTEMS
The Challenge of the 21st Century

PROCEEDINGS



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SECTION 1

IN SITU AND EX SITU CONSERVATION OF THE GENE POOL OF TREES IN SERBIA

Vera LAVADINOVIĆ[1], Vasilije ISAJEV[2], Aleksandar LUČIĆ[1]

Abstract: *The wealth of forests in Serbia, from the aspect of the number of woody species, their diversity and primary gene centres, is unique in Europe. Forest resources in Serbia include 205 autochthonous tree species and shrubs (175 broadleaves and 35 conifers), with primary gene centres of a large number of endemic and endemic-relic species - Pinus peuce, Pinus heldreichii, Picea omorika, Fraxinus pallisae, Forsythia europaea, Corylus colurna, etc.*

Aiming at the conservation of gene pool in situ in Serbia, five National parks, twenty Regional Parks, 114 reserves and 310 seed stands of economically significant species of conifers and broadleaves, total area 2108 ha, have been designated.

The conservation of genetic resources ex situ includes the reproduction of forest populations and superior genotypes by the establishment of specialised forests, arboreta and living archives, provenance tests, progeny tests, clonal tests and seed orchards.

The balance model of genetic structure of tree and shrubs populations reveals their new characters and requires further research.

This paper surveys the activities which have been carried out in Serbia in the last fifty years in the aim of conservation, testing and utilisation of gene pools of tree species in situ and ex situ.

Key words: gene pool, *in situ* and *ex situ* conservation, seedling seed orchards.

1. INTRODUCTION

The basic principles of genetic resource conservation are essentially the same for all living organisms. However, the methods vary depending on the goals of conservation, distribution and biological nature of the object which is conserved (FAO, 1989). The term “method” is often used to denote different concepts, such as *in situ* conservation, *ex situ* conservation, ecosystem conservation, species conservation, static conservation, dynamic conservation, etc. Species, ecosystems, populations, and individuals are considered as objects of conservation and the term “method” is used to make the difference between different methods of conservation of genetic resources, such as *in situ* conservation, ex *situ* conservation, dynamic or static, active or passive conservation.

The definition of *in situ* conservation generally is not quite clear and the term is used in different ways. There are ambiguities in the part of *in situ* conservation which refers to wild species, on the one hand, and the domestic species, on the other hand. *In situ* conservation means that the population remains within its community, in the environment in which it is developing. The term is often related to the wild, naturally regenerating population in the conservation area. However, *in situ* conservation is also integrated in forest management, and in the multiple use forestry. Actually, *in situ* conservation is focused on conservation of genetic resources in their source ecosystems disregarding the human interference in that ecosystem. In a simple way, the germplasm is conserved at the place where it has been discovered, or where it is naturally located,

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or where it has developed the characteristic properties resulting from the cultivation. *In situ* genetic conservation, therefore, includes the conservation of the populations through generations, to preserve the evolution potential by the adaptive or randomly developed genetic structures within the species.

2. MATERIAL AND METOD

The research in the past period consisted of several successive activities, such as: the study of the nature of phenotype variability of trees in large and small populations, enhancement of the methods of mass and individual selection, application of related and distant hybridisation, analysis of morphometric characteristics, study of interdependence of growth and development characteristics of the analysed genotypes and their progeny. Forest populations in Serbia in which gene pool conservation of trees is performed belong to: natural populations managed as specific purpose forests – nature reserves, national parks, seed stands, groups, and individual trees, commercially managed natural populations and artificial populations in which wood production is not the main purpose – live archives, provenance tests, progeny tests, clonal tests and seed orchards.

Aiming at the conservation of gene pool in situ in Serbia, five National Parks, twenty Regional Parks, 114 reserves and 310 seed stands of economically significant species of conifers and broadleaves, total area 2108 ha, have been designated. Figure 1.

In situ method of conservation has several advantages. It is the dynamic method of conservation, which allows the process of natural selection, i.e. the future evolution potential of gene bank and the adaptation capacity of the population. This is important because no species is static, it is in constant interaction with its environment and in competition with other species in the ecosystem. For the species to survive in future, they have to be able to compete with other species, and they will keep their competition capacity only if their evolution process is undisturbed. This aspect is particularly important today in worldwide climate changes which result from global

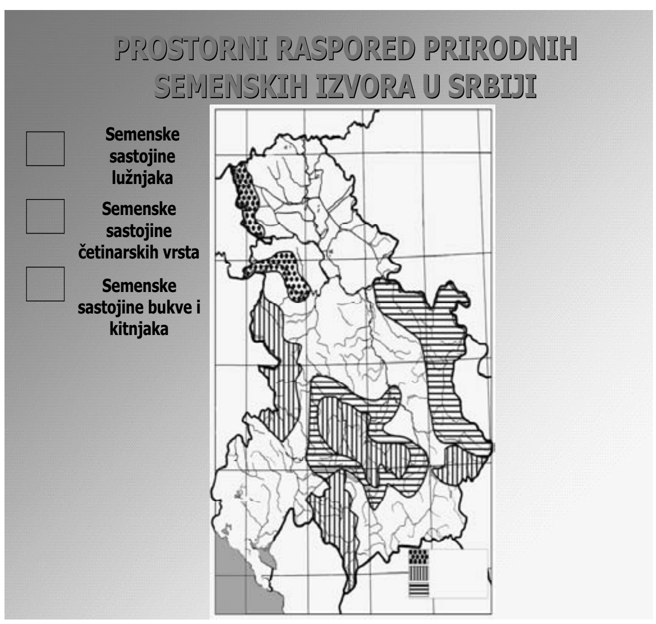

Figure 1. Spatial distribution of natural seed sources in Serbia

warming. Actually, *in situ* conservation method has a general advantage of the conservation of the function of an ecosystem, rather than the conservation of populations or species, meaning that it normally includes a great number of related plant and animal species, including all their interactions. Another advantage of *in situ* conservation, which is most important for the species evolution development, is the fact that it is easier, much safer and financially much more profitable to conserve the existing population of the species in their natural site, than in *ex situ* conditions. This is particularly true for woody species, as they require large space for the conservation of several thousand of individuals. Plant genetic resources have an important socio-economic value and they are a biological base, directly or indirectly, for the supply of food for each individual in the biosystem. The diversity of plant genetic resources has been significantly extincted both in forestry and in agriculture. The serious promotion of conservation and sustainable use of genetic diversity is aimed at the priority of important socio-economic values of plant species, as the essential base for the supply of food raw materials and sustainable development.

The goal of the conservation of forest genetic resources worldwide is the management and conservation of the existing genetic diversity of the thousands of species of the known or potential socioeconomic and ecological value. However, the levels and the distribution of genetic variability of each species are in a constant process of changes under the effect of major forces of evolution. Therefore, the central issues of conservation should be the evolution processes, which change and enhance the genetic diversity, and not the efforts for the conservation of exclusively present distribution of variability, as the final form (Namkoong *et al.* 1997; Namkoong 2001).

In Serbia, *ex situ* populations or collections of forest trees are established in the aim of:
- conservation of populations or individuals which are threatened by physical destruction, when conservation *in situ* is not possible,

-to ensure relatively easy production of reproductive material,

-to supplement or replace *in situ* conservation of unique populations which are endangered at their natural sites.

Ex situ conservation is consequently very useful when it is desirable to maintain well-defined seed sources for commercial plantations without expensive systems of cultivation. At the same time, the produced reproductive materials are adapted to the ecological conditions in the forest. This is an evolution and dynamic approach to gene conservation, where both natural processes and management determine the genetic structure of the following generations. Seed orchards and clonal archives are the examples of static *ex situ* units of conservation, because there are no changes in their genetic structure. Still, they are important populations in the cultivation programme, which will evolve based on the information acquired in field investigations, where both natural and anthropogenic selection occur simultaneously.

Ex situ conservation is a form of conservation and enhancement of genetic diversity by its direct involvement in the processes of plant breeding. Basic elements of *ex situ* conservation are related to the need of identification, conservation and enhancement of intraspecific variability. The objects, such as seed orchards, progeny tests, live archives and provenance tests present a very important form of *ex situ* conservation of the species endangered by extinction. Efficient management of forest genetic resources is the key element in future conservation in forestry. Genetic diversity is essential both for long-term and for short-term productivity of forest ecosystems.

Conservation, testing and utilisation of the gene pool of tree species covers several successive activities: a) study of the nature of phenotype variability in large and small populations, b) enhancement of methods of mass and individual selection, c) application of related and distant hybridisation, d) analysis of morphometric characteristics, e) study of interdependence of growth and development characteristics of the analysed genotypes and their progeny (Isajev, V. *et al.* 1988). The activities of gene pool conservation and utilisation include its conservation *ex situ* – by the reproduction of forest populations and superior genotypes by the establishment of specialised forests, arboreta and live archives, provenance tests, progeny tests, clonal tests, and seed orchards (Gustafsson, A. 1950, Jovanović, M. 1972, Isajev, V. *et al.* 1995). This paper presents the preliminary results of multiannual analyses performed in specialised cultures - seedling seed orchards of Serbian spruce, Austrian pine, and Heldreich maple, in the aim of testing the genotypes of parent individuals, as well as their half-sib lines.

The specialised plantations - seed orchards and clonal archives are the examples of static *ex situ* units of conservation, because there are no changes in their genetic structure. Still, they are important pilot objects in the programme of testing the genetic potential of initial populations, because they follow the effects of simultaneous natural and anthropogenic selection.

The objectives of seed orchard establishment are the populations which will to the highest possible degree maintain the original genetic variability and allow the long-term adaptation to the local conditions of the planting site. In addition to the conservation of the original genetic variability, they are used also as the sources of reproductive material for commercial forestry. The establishment of generative seed orchards of the first generation at the locations with different micro-ecological conditions present a type of «insurance» for the potential unexpected losses, as well as the form of testing of the extent of adaptations to the wide spectre of different site conditions.

In Serbia, in the last decades of the last century, several generative seed orchards were established, which present original solutions based on the selection of species, areas and planting schemes, so they can be used as the models also for other species, within the activities of conservation of genetic resources *ex situ*.

SERBIAN SPRUCE SEED ORCHARD. Based on investment programme of the Centre for Forest Seed in Kremna, a Serbian spruce generative seed orchard was established in 1987 on the area of 2.7 ha in the village Godovik near Požega (Isajev, V. 1987). The orchard consisted of 5959 seedlings aged 2+3', produced in the nursery in Požega.

The seedlings of the same family were planted in one block, by random distribution in the form of square planting pattern 2 x 2 m, Figure 2.

By the category and genetic constitution, the seed and planting material obtained from the seed orchard is:

A. From free pollination in half-sib seed orchard:

Figure 2. Planting pettern of Serbian sprice half sib linies in blocks

a) 50 types of half-sib families, plants intra-family,

b) 200 types of inter-family hybrids of family margin lines,

B. From controlled hybridisation:

c) 50 self-fertilised families

d) 223 intraspecific hybrids, and

e) interspecific hybrids with spruce, Sitka spruce, Japanese spruce and other compatible species.

The results of comparative analyses of seeds and planting material of the above categories and genetic compositions ensure the selection of parent individuals with a good general and specific combining ability for the establishment of clonal seed orchards of the second generation, or specialised seed orchards of the second generation, to ensure the production of genetically viable and superior seeds and planting material. Which of these genetic compositions of the reproductive material will be in our interest depends on the following factors: self-fertilised or allogamic mother plants, silvitechnical conditions for which the nursery stock is produced, and market demands. All the factors should be analysed, so that already at the beginning of seed or planting material production, it is clear what genotype variety is desired (pure line, pure variety, single line, multi-family, mixture variety, population variety, synthetic variety, hybrid variety, mutant variety, clonal variety, etc.).

AUSTRIAN PINE SEED ORCHARD: Austrian pine generative seed orchard on Jelova Gora, area 2.70 ha on site *Fagetum montanum* Rud. s.l., was established in 1991 of 5422 two-year-old seedlings in 40 half-sib lines of the selected test trees in seed stands Šargan-Mokra Gora and Crni Vrh-Priboj. Figures 3. This seed orchard was established by the principle of meta-population structure, i.e. it consists of five repeated, more or less related structures-suborchards or blocks which ensure a higher yield. Economicity, genetic diversity, better adaptation, as well as stability and the possibility of production of varietal seed (Tucović, Isajev 1991).

Austrian pine seed orchard with 40 half-sib lines, represented each by three repetitions in each of the five suborchards and with dynamic environmental factors - altitudinal difference of 20 m, two exposures, and two soil types present the first generative seed orchard of this species, of meta-population structure. Based on its structure, it is possible to realise the effect of genetic development mechanisms and regulation mechanisms, on the one hand and on the other hand,

Figure 3. Austrian pine seed orchard at Jelova Gora

to realise the effect of ecological mechanisms which will have a favourable effect on the successful gene pool conservation of this species.

The research of Austrian pine variability in the juvenile stage of development and the interdependence of morphological-physiological parameters is multiply significant, both for science and for practical application, because they present the base for the enhancement of production of good-quality seed and planting material with desired properties. The results will be used as the guidelines for the enhancement of methods of Austrian pine seed orchard establishment of the second, third and later generations. The analysis of interdependence of seedling characteristics and development in this orchard are a contribution to the study of Austrian pine variability, as the base for directed utilisation of the genetic potential of this species. The results point to the possibility of synthesis of the varieties with desired ratios of individual elements of growth and other properties, which will enable a higher yield of future cultures established on different sites.

SEED ORCHARD OF HELDREICH MAPLE: Aiming at the study of the gene pool of Heldreich maple natural populations, Forest Estate "Golija" - Ivanjica established in 1994 a Heldreich maple generative seed orchard at the site called "Perkovići-Strane", compartment 12, subcompartment C of the Management Unit "Kovilje - Rabrovica" managed by State Enterprise "Srbijašume" (Ćurčić, G. 1997; Ćurčić, G. *et al.* 1999). The altitude of the location is 950 to 1020 m, exposure northeast, and the site belongs to *as. Fagetum montanum* Rud. s.l. The seed orchard area is 1.05 ha,.

Heldreich maple generative seed orchard is established of 26 half-sib lines planted in 6 blocks with 4 repetitions.

3. CONCLUSIONS

The efficient management of forest genetic resources is the key element in the future conservation in forestry. Genetic diversity is essential, both for long-term and for short-term productivity of forest ecosystems.

In addition to genetic potential conservation and testing *in situ* in natural populations at different sites, the establishment of specific plantations ensures the conditions for biodiversity testing, as well as for the study of the magnitude of the potential variability *ex situ*. Starting from the floristic, genetic and applicative potential of Serbian spruce, Austrian pine and Heldreich maple, this paper presents the multiannual research aiming at the conservation and directed utilisation of their gene pool by the establishment of specialised cultures.

The study results enable a better knowledge of the production and adaptation potential of the analysed species. Seed orchards and pilot objects, as specialised cultures should contribute not only to the conversion of the potential genetic variability into free variability, as the base of the directed utilisation of gene pool of trees, but also as the polygons for testing and conservation of species biodiversity.

The presented goals and methods, as well as the results of genetic evaluation of Serbian spruce, Austrian pine and Heldreich maple in seedling seed orchards are a modern approach to the conservation and testing of their gene pool, as well as for planning and establishment of future cultural communities of these species.

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POMOLOGICAL CHARACTERISTICS OF THE SUPERIOR SELECTIONS OF *CORYLUS AVELLANA* AND *C. COLURNA*

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Abstract: *Four selections of European filbert and Turkish hazel each were singled out for their prominent characteristics in an examination in Eastern Serbia over the 1998-2003 period. Coarseness, form and weight of nuts and kernels, as well as kernel chemical content, were analysed. Yielding potential was investigated as a proportion of nuts in filbert and hazel inflorescences. Average nut coarseness of the C. avellana L. selections was 18.55x14.95x12.97 mm, and of C. colurna L. 16.57x15.0x 10.77 mm, while average kernel coarseness was 14.22x9.75x8.25 mm and 12.97x 10.17x 6.3 mm, respectively. Nut weight of the former was 1.65-1.80 g, and of the latter 1.03-1.75 g, while kernel weight ranged 0.59-0.79 g, and 0.42-0.57 g, respectively. The respective kernel contents were 34.9-46.2%, and 32.6-40.8 %. The occurance of shriveled nuts was minimal, appearing in three selections of C. avellana (1.2-8.8%), and three selections of C. colurna (1.4-5.7%). The pest Curculium nucum was observed in only two selections of C. colurna L., ranging from 1.0 to 1.6 %. Oil content in the nuts of the selected C. avellana L. trees was 44.6-49.1 %, and 48.6-53.8 % in those of C. colurna L. Crude proteins amounted to 10.8-12.3 % and 10.4-11.7 %, and mineral matter content to 2.6-2.8% and 2.1-2.6 %, respectively. For the chosen selections of the forest hazel-nut trees is characteristic, that there are 1 to 4, and 6 fruits together in a inflorescence. Other than selection 1/98, in all the other selections prevail the inflorescences with 1 or 2 fruits together. The inflorescences of the C. colurna L. are with 1 to 8, and with 13 fruits. Nevertheless of deferent prevailing, there are most inflorescences with 3 to 6 fruits together.In the same time this is an indicator of high productivity of Turkish hazel.*

Key words: European filbert, Turkish hazel, selection, nut, yielding potential

1. INTRODUCTION

European filbert (*Corylus avellana* L.) and Turkish hazel (*C. colurna* L.) are widespread across eastern Serbia, mostly sharing their phytocenoses with various other forest plants, or growing in homogenous strands. The forms of European filbert and Turkish hazel trees growing spontaneously in natural environments have generative origin and make a significant gene pool of various traits. Considering the existing deficiency in biological high-quality food and prospects for such production, European filbert and Turkish hazel nuts provide an excellent fresh material for the purpose.

The biodiversity and pomological and technological properties of European filbert and Turkish hazel have been studied under different agroecological conditions by Mitrevski et al. (1983), Manusev (1988), Mitrovic et al. (1997) and Miletic et al. (1997), while Bulatovic (1985) has reported on their yielding potentials. Based on their work, Pejkic (1980) and Ninic-Todorovic

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(1987) proceeded to isolate their selections. Krstic-Pavlovic et al (1990) and the aforementioned authors have pointed out the value, quality and medicinal effects of their nuts. Years of investigation of the populations of European filbert and Turkish hazel in eastern Serbia have resulted in identifying some superior *in situ* selections for that purpose, which is also the subject of this article. Our research and our selections make a contribution to preserving the biodiversity, providing high-quality multiplication and supplying fresh material for the production of biologically high-quality food.

2. MATERIALS AND METHODS

The investigation was carried out across a wide region of eastern Serbia, where European filbert and Turkish hazel grow in large numbers. The analysis focused on shrubs and trees with particularly luxuriant appearace, vitality, high and regular yield, tolerance to low temperatures and to the hazelnut weevil (*Curculium nucum*). Close attention was also focused on the coarseness, shape and weight of nuts and kernels, and kernel chemical composition. Yielding capacity, i.e. the proportion of nuts to an inflorescence, was also carefully studied.

We selected four trees of each species out of a large number of studied shrubs and trees that showed the best results over a previous period of several successive years (1998-2003). The nuts collected from them were analysed for the following properties: nut and kernel coarseness (length, width, thickness) measured by square callipers, and weight measured on a high-precision technical balance. Oil content was determined by nuclear magnetic resonance, crude proteins by the Kjeldahl method, and mineral matter by burning off. The article presents data collected over several years and statistically processed by the analysis of variance and Duncan`s test. (R>0.01)

3. RESULTS

Data on the coarseness and shape of nuts and kernels of the isolated selections of European filbert and Turkish hazel are presented in Table 1.

Table 1. Fruit and kernel size of a European filbert and Turkish hazel.

Species	No.	Fruit				Kernel			
		Length mm	Width mm	Thickness mm	Shape factor	Length mm	Width mm	Thickness mm	Shape factor
C. avellana	1/98	20.7a	16.5a	13.7a	0.73b	15.6a	10.2ab	8.7b	0.60b
	5/99	17.6b	14.9ab	13.0a	0.88a	14.1ab	11.7a	10.1a	0.77a
	6/00	18.0ab	14.0b	12.6a	0.74b	13.7ab	8.6b	6.9c	0.56b
	8/01	17.9ab	14.4ab	12.6a	0.75b	13.5b	8.5b	7.3c	0.58b
	Mx	18.55	14.95	12.97	0.77	14.22	9.75	8.25	0.62
C. colurna	2/98	16.2a	16.5a	12.0a	0.88a	13.0ab	12.5a	7.9a	0.78a
	3/98	17.2a	14.5bc	10.3bc	0.72b	13.9a	10.4b	6.5b	0.61b
	7/01	16.5a	15.6ab	11.1ab	0.81ab	12.9ab	9.4c	5.3b	0.57b
	8/01	16.4a	13.4c	9.7c	0.70b	12.1b	8.4d	5.5b	0.57b
	Mx	16.57	15.0	10.77	0.77	12.97	10.17	6.3	0.63

The nuts of European filbert are generally mostly medium large or large. Those of the isolated European filbert selections were found to have coarseness ranging 17.6-20.7x14.0-16.5x12.6-13.7 mm and Turkish hazelnuts 16.2-17.2x13.4-16.5x9.7-12.0 mm, while kernel coarseness was 13.5-15.6x8.5-11.7x6.9-10.1 and 12.1-13.9x8.4-12.5x5.3-7.9 mm, respectively. The average nut coarseness of all selections of European filbert was 18.55x14.95x12.97 mm, and of Turkish hazel 16.57x15.0x10.77 mm, while average kernel coarseness was 14.22x9.75x8.25 and 12.97x10.17x6.3 mm, respectively. The findings agree with the results of an analysis of variance and Duncan`s test.

The average index of roundness of European filbert nuts was 0.77 (0.73-0.88), and of Turkish hazel 0.77 (0.70-0.88). Similar data was obtained for the kernel index of roundness, i.e. 0.62 (0.56-0.77) and 0.63 (0.57-0.78). This parameter identified the nuts and kernels of all selections of European filbert and Turkish hezel as having elongated shape. Nut weight of the European filbert selections ranged 1.65-1.80 g, and of Turkish hazel 1.03-1.75 g, giving the average values of 1.71 g and 1,34 g, respectively. On the other hand, kernel weight of European filbert was 0.59-0.79 g and of Turkish hazel 0.42-0.57, the average being 0.66-0.50 g. Depending on weight, kernel content of the European filbert selections was 34.9-46.2 and of Turkish hazel selections 32.6-40.8%, or 38.55 and 38.05% on the average, Table 2.

The proportion of shrivelled nuts was minimal in the chosen selections. They accounted for 1.2-8.8% in three European filbert selections, and 1.4-5.7% in three selections of Turkish hazel. A special impact on the European filbert trees came from an infestation and nut injury by the pest *Curculium nucum*. The pest was only found in the nuts of two selections of Turkish hazel, Table 2. The injury, however, was insignificant, measuring 1.0-1.6%, which was fairly good considering a need for pesticide treatment. Oil content in the kernels of the European filbert selections was in the average 49.95 % (44.6-49.1%), and in Turkish hazel selections it was 52.07%(48.6 - 53.8%),content of crude protein was 11.67%(10.8-12.3%) and 10.95%(10.4-11.7%) and mineral matter content in the ashes was 2.72%(2.6-2.8), and 2.4%(2.1-2.6%). All selections were found to have several excellent fruit characteristics. Highly significant differences between the selections were found only regarding oil content.

Putting the yielding potential into focus, we studied the number of nuts per inflorescence, Table 3.

Table 2. Fruit mass and chemical content of kernel.

Species	No.	Fruit mass (g)	Kernel mass (g)	Kernel content (%)	Hollow nuts (%)	C. nucum %	Oil content (%)	Crude proteins (%)	Mineral matters (%)
C. avellana	1/98	1.80a	0.63b	35.0c	8.8a	0.0	48.1ab	12.1a	2.8a
	5/99	1.71ab	0.79a	46.2a	0.0d	0.0	44.6c	10.8b	2.7a
	6/00	1.65b	0.63b	38.1b	1.2c	0.0	46.0bc	11.5ab	2.6a
	8/01	1.69ab	0.59b	34.9c	2.5b	0.0	49.1a	12.3a	2.8a
	Mx	1.71	0.66	38.55	3.12	0.0	46.95	11.67	2.72
C. colurna	2/98	1.43b	0.56a	39.2b	3.6b	1.6a	53.8a	10.4a	2.5ab
	3/98	1.03d	0.42b	40.8a	5.7a	0.0c	52.7a	10.9a	2.1b
	7/01	1.75a	0.57a	32.6c	0.0d	1.0b	53.2a	10.8a	2.4ab
	8/01	1.16c	0.46b	39.6b	1.4c	0.0c	48.6b	11.7a	2.6a
	Mx	1.34	0.50	38.05	2.67	0.65	52.07	10.95	2.4

Table 3. Number of nuts per inflorescence of European filbert and Turkish hazel

Sp.	No.	Nuts per inflorescence (%)												
		1	2	3	4	5	6	7	8	9	10	11	12	13
C.avel.L.	1/98	21.8	19.3	20.5	20.5	11.5	6.4							
	5/99	32.2	42.3	22.0	3.5									
	6/00	42.1	35.0	13.7	6.7	2.1	0.4							
	8/01	30.0	26.7	23.3	20.0									
	Mx	31.5	30.8	19.9	12.7	3.4	1.7							
C.colur.L.	2/98	0.6	0.8	16.4	21.9	28.4	21.3	5.1	3.0	1.8	0.5	0.2		
	3/98	0.9	1.5	15.6	20.7	30.1	18.4	9.3	3.5					
	7/01	1.3	1.2	15.4	22.1	29.4	20.9	4.0	2.9	2.2	0.4	0.1	0.1	
	8/01	0.9	0.9	16.0	20.8	23.1	18.4	9.3	5.1	2.3	1.9	0.6	0.4	0.3
	Mx	0.9	1.1	15.8	21.3	27.8	19.8	6.9	3.2	1.6	0.7	0.2	0.1	0.1

The European filbert selections were characterized by inflorescences containing between 1 and 4, or 6. fruits together. Other than selection 1/98, in all the other selections prevail the inflorescences with 1 or 2 fruits together. The inflorescences of the *C. colurna* L. are with 1 to 8, or 13 fruits together. Nevertheless of deferent percentage, there are most inflorescences with 3 to 6 fruits together.In the same time, this is an indicator of high yielding potential of Turkish hazel.

4. DISCUSSION

With regard to the generative reproduction of European filbert and Turkish hazel trees, their progeny is heterogenous with different nut coarsenesss and weight. Mitrevski et al (1983) had reported nut coarseness of European filbert selections ranging 17.0-23.4x16.0-19.6x12.7-16.0 mm, nut weight of 1.45-2.08 g, kernel weight of 0.48-1.15 g and kernel content of 31.0-53.0%. In a study on Pešter Plain, Pejkić (1980) had selected European filbert forms measuring 14.4-22.1 mm nut length, 14.1-16.9 mm width and 1.13-1.51 g weight.

Similar findings have been reported for Turkish hazel. Ninic-Todorovic (1987) reported biotypes with 16.4-18.6x14.4-17.8x11.0-15.8 mm nut coarseness, 1.17-2.54 g nut weight, and 0.52-0.71 g kernel weight. Studying the biodiversity of Turkish hazels in Serbia, Mitrovic et al. (1997) found an average nut coarseness of 13.8-19.1x11.6-19.1x9.0-16.7 mm, kernel coarseness of 11.3-15.4x8.0-13.4x5.7-10.2 mm, nut weight of 0.63-2.86 g, kernel weight of 0.24-0.86 g and kernel content of 25.9-38.1%.

As reported Manusev (1988), hollow shells or shrivelled nuts are caused by factors other than parasite activity. Infestation by *Curculium nucum* is detrimental and a factor discouraging a more widespread cultivation of those selections.

Fresh filbert and hazel nuts provide a rich and high-calory nourishment with high energy and dietary potentials. This agrees with data reported on European filbert and Turkish hazel selections. Krstic-Pavlovic (1990) reported oil content in the kernels of European filbert as ranging 33.9-47.9%, while Miletic et al (1997) found it to range 41.7-50.7%, crude proteins 8.7-13.1% and ashes 2.4-2.8%. These findings agree with those showing 60.58-64.62% oil content in Turkish hazel kernels, Ninic-Todorovic (1987). Mitrovic et al. (1997) reported an oil content of 47.38-65.15%, crude proteins of 17.9-16.1% and mineral matter 2.04-2.63%.

Regarding kernel chemical composition, European filbert and Turkish hazel lag behind the cultivars, Miletic (1994), but it still shows their worth and secures a possibility for them to be used fresh or processed. Besides, their habitats are mostly situated in ecologically favourable environments, i.e. on and around mountainous areas far from industrial or other pollution, so that their nuts meet the standards of biologically high-quality food. It is worth mentioning that European filbert and Turkish hazel grow spontaneously in natural environments and yield nuts without any special care, cultivation, fertilization or protection from diseases and pests. Adding to these facts are the potentials and value of their nuts as nourishment, which is by all means a special merit of the *Corylus* genus.

Filberts and hazels are characterized by multiple nuts clustered in their inflorescences. Manusev (1988) had reported 1-10 nuts borne by the inflorescences of certain cultivars, with predominating 2 and 4 nuts to an inflorescence. According to Bulatovic (1985), the number of nuts borne by an inflorescence is 1-4, with predominating 1 or 2 nuts. Miletic et al (1997) reported inflorescences with up to five or more nuts, the majority however being single or paired.

The isolated selections of European filbert and Turkish hazel were characterized by a high yielding potential. As they grow and yield at different habitats and under different microclimatic conditions, the true value of the selections can be evaluated through their collection and cultivation under uniform conditions. Besides, they are able to grow spontaneously in natural environments without any agricultural practices applied. The nutritive area is mostly limited and competitive with other plant species. Their collection and intensive cultivation could further clarify their full productive capacities, properties and nut qualities.

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ECTOMYCORRHISA IN SPRUCE SEEDLINGS PRODUCTION

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Abstract: *The influence of ectomycorrhizal fungi on spruce (Picea abies (L.) Karst.) seedlings growth ,nutrition and water status is presented.*

Seedlings were produced in nursery by standard procedure. The origin of seeds was spruce seed stand on Jastrebac Mt. Liquid culture of six ectomycorrhizal fungi, common symbionts of Picea spp.: Boletus badius, Hebeloma crustuliniforme, Pisolithus arrhizus, Suillus bovinus, Rhizopogon sp. was used in the experiment with four replicates with 50 seedlings. Roots were dipped in this gelatinous mass which has covered them.

Morphometric and some physiological properties were analyzed before and after first and second vegetative season. After the first season the survival percent was better for 18% in treated plants. It was significant influence of ectomycorrhizal fungi on seedling height (average for 2.4 cm); number of new twigs was more numerous for 1.3, root collar diameter for 1.2 mm and root volume for 0.7 cm^3.

It was higher content of mineral elements (N,P,K,Ca and Mg) in needles in treated plants after first and especially after second season. Water regime properties, water potential, transpiration intensity, total water content, were also better in treated plants.

Key words: ectomycorrhiza, spruce, growth, nutrition, water regime

1. INTRODUCTION

Spruce (*Picea abies* (L.) Karst.) is the most common conifer forest species of the North hemisphere. It is very common in Serbia in the higher parts of mountainous region. It can be high about 40 m and in diameter about 1 m. Root is not deep, develops on surface area of the soil and has a good formatted lateral roots. Spruce is one of the most used species for afforestation in the region.

As an ornamental plant it is used for the mountains region regulation, especially for degraded areas. It is also used in ornamental plant production for grafting methods in various conifer cultivars of genus *Picea* production, pendulous, globosa, fastigiata etc. as well as New year trees.

Spruce root has a special symbiotic community with ectomycorrhizal fungi. Ectomycorrhiza is present at a great number of forest tree species. The symbiotic union is realised by fungus hyphae which covers the surface of root by great density and makes contact with surrounding supstrate (fungous trump) and penetrates in into the intercellular areas of the root making so called Hartigs-network where the exchange between fungi and plant root is realised through apoplast.

The optimal water status of forest woody plants is important for adequate nutrition and physiological condition in later stages of onthogenic development (George, E. et al. 1996).

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Mineral nutrition is the most important method for improving the quality and biomass production increment at forest woody plants, especially in young cultures (Ingestad 1993). According to this, it is necessary to continue with scientific research of specific needs of forest and ornamental plants for mineral nutrition (Rennenberg et al. 1997).

The aim of this work was to improve some experience in spruce nursery stock production.

2. MATERIAL AND METHODS

Spruce seedlings age 2+0 were produced in nursery in Krusevac, enterprise Srbijasume by standard procedure. The origin of seeds was spruce seed stand on Jastrebac Mt. Liquid culture of five ectomycorrhizal fungi, common symbionts of *Picea* spp.: 1.*Boletus badius, 2.Hebeloma crustuliniforme ,3.Pisolithus arrhizus, 4.Suillus bovinus, 5.Rhizopogonsp* and 6. *mixture.*The autor of the preparation is Dr. Miroslav Vosatka, Institut for Botany, Akademy of Science, Pruhonice.

There were six treatmants, five with only one fungus and one with the mixture as it is suggested for commercial use. The liquid culture of fungi was mixed with "dipping" gel and perlite and used for root treatment. Roots were dipped in this gelatinous mass which has covered them. Control plants were treated with gel without fungi. All treatments and the control were applied in 4 repetitions with 25 plants in each. The experimental plot was in nursery Topcider- JP Srbijasume on the area of 10x5 m, with planting space 20 cm (foto.2). After the first season the survival percent was calculated.

Morphometric and some physiological properties were analyzed before and after first and second vegetative season. It was seedling height ; number of new twigs , root collar diameter and root volume.

Also a needle mineral elements N,P,K,Ca and Mg content were analysed by Kjeldahl, colorimetric and AAS method. Water regime properties, water potential, transpiration intensity, needle water content were determinated by "pressure chamber" and gravimetric methods.

3. RESULTS AND DISCUSION

Analysis of the survival percentage shows that it was good at plants treated with fungi mixture, about 68%, and less at the treatment 1, about 40%, and at the control plants it was 50% (graph. 1).

Plant height was significantly higher (foto.1) at the treated plants with fungi mixture 19,5 cm, comparing to control 17,1 cm and the beginning of the vegetation 15,8 cm (graph. 2).

Number of lateral twigs at plants treated with fungi mixture was average 7,7 comparing with the beginning of the vegetation 5,2 and control 6,4 , but there were not significant differences between treatments. (graph. 3).

Root collar diameter, the parameter which is the most important for woody seedling quality, was the greatest at seedlings treated with fungi mixture 3,3 mm and at control seedlings it was 2,6 mm (graph. 4).

Root volume was also the best at mixture treatment 3,7 cm^3 comparing to control where it was 3 cm^3 and at the beginning of the vegetation 2,7 cm^3 (graph. 5).

Content of basic macronutrients N,P,K, as well as Ca and Mg in needles shows the increment at all treatments comparing to the beginning of the vegetation and also better supply at the seedlings treated with mixture. Significant increment was noticed at nitrogen content 1,2% comparing to 0,8% at control plants, at potassium where mixture treatment plants had 0,83% in needles and at control plants it was 0,68% and at magnesium content it was 0,26% at plants treated with fungi mixture comparing to control with 0,18%. According to this analysis it was detected a slight lack of Mg which was also seen in a chlorosis appearance which was removed by mineral nutrition which was done by foliar method. (graph. 6-10)

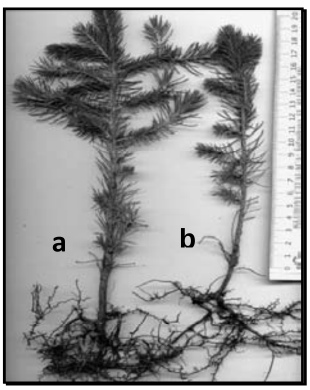
Water regime properties, water potential, transpiration intensity, needle free water content shows that the water supply is the best at spruce plants treated with fungi mixture (ψ=-6Mpa) and statistically significant differences were calculated at needle total water content (67%) (graph. 11, 12, 13).

Optimal water regime of plant is very important for the best uptake and use of mineral elements because the hydrature of cell cytoplasm determinates the intensity of biochemical and physiological processes in which those elements are involved (Djukic et al. 1996, 1990).

It was also identified that fungi hyphae network disappears at the place where cells died and stay only around alive root cells. It is also interesting that fungi besides the main task, to enable better water and mineral uptake for plant, fungi cells exudates a specific substances elicitors which provoke various reactions at host pant such as the better synthesis of nucleic acids, enzymes, hormones and others and by this have a additional positive effect.

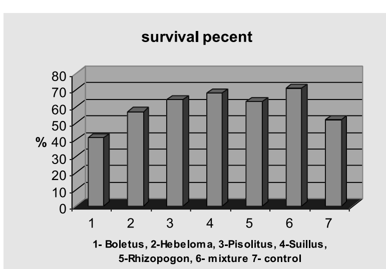
Better mineral uptake has an influence on growth and better nursery stock quality as well as better physiological condition and resistance to unfourable environmental conditions such as extreme temperatures, water stress, heavy metals, chemical pollutants, air pollution, plant diseases, insects and other.

In this experiment the seedlings were produced in nursery with the same technology and under the same ecological conditions, of the same provenance and age, so the differences in all parameters are the result of the ectomycorrhizal fungi reatments.

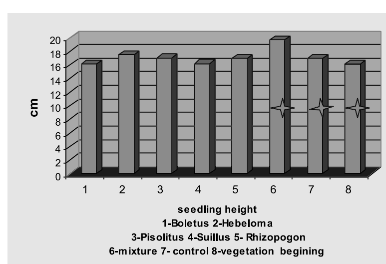


Sl.1. Average seedlings at the end of I vegetation season a/ mixture, b/ control

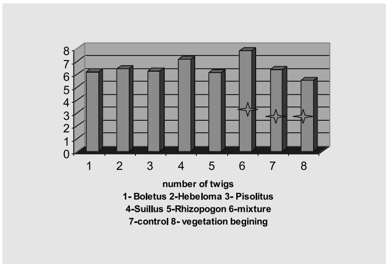
Sl. 2. Experimental plot in nursery



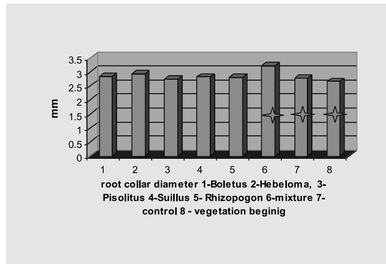
Graf.1. Seedling survival percent



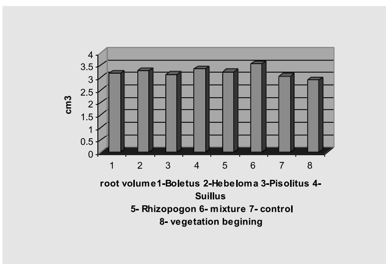
Graf. 2. Seedling height



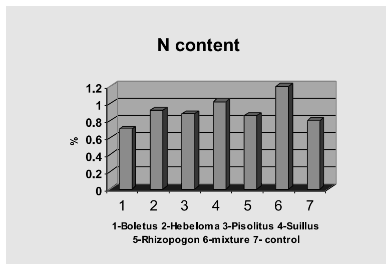
Graf. 3. Number of lateral twigs



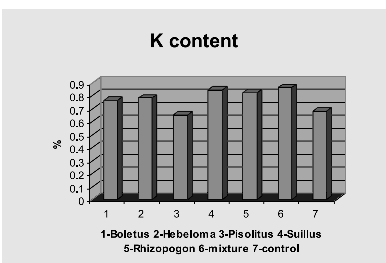
Graf. 4. Root collar diameter



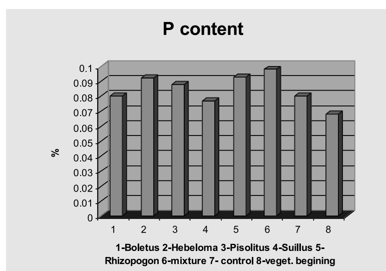
Graf. 5. Root volume



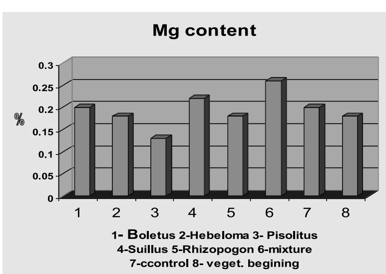
Graf. 6. Needle N contetnt



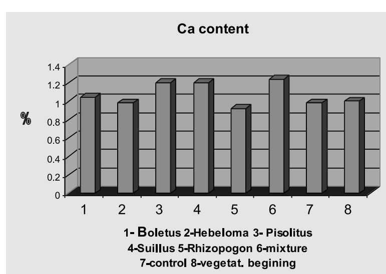
Graf. 7. Needle K content



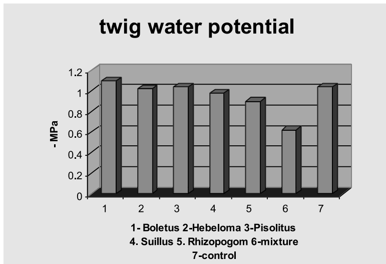
Graf. 8. Needle P content



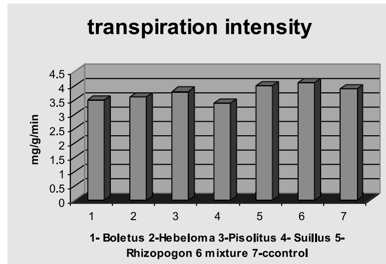
Graf. 9. Needle Mg content



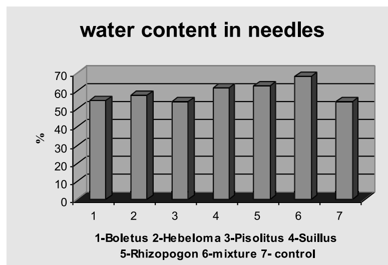
Graf. 10. Needle Ca content



Graf. 11. Twig water potential



Graf. 12. Transpiration intensity



Graf. 13. Total water content

4. CONCLUSIONS

The results of the analysis of the data of the influence of fungi treatments on growth, nutrition and water regime of spruce seedlings shows

The seedling survival percentage was the best at the seedlings treated with the mixture of ectomycorrhizal fungi**.**

Morphometric properties were significant influenced by ectomycorrhizal fungi, on seedling height (average for 2.4 cm); number of new twigs was more numerous for 1.3, root collar diameter - 1.2 mm and root volume for 0.7 cm^3.

Physiological properties, content of mineral elements (N,P,K,Ca i Mg) in needles in mixture treated plants were higher and water regime properties (water potential, transpiration intensity, total water content) were also better in treated plants.

As seedlings were produced in nursery with the same technology, under the same ecological conditions, of the same provenance and age, the differences in all parameters are the result of the ectomycorrhizal fungi treatments.

For the good valuation of nutrition state and need, it is necessary to have also data of specific needs in the various stages of plant development.

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MORPHOLOGICAL-ANATOMICAL CHARACTERISTICS OF NEEDLES OF MOUNTAIN PINE IN THE AREA OF NP "SUTJESKA"

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Abstract: *The richness of forest ecosystems of the NP "Sutjeska", and particularly numerous communities which belong to the families: Pinaceae* Lindl., *Cupressaceae* F.W. Neger., *Fagaceae* Dum.*, and also numerous other natural phenomena, were the reasons why the area was designated as the National Park in 1965. The total area of NP "Sutjeska" is 17,250 ha. Forests and forest lands cover 10,595.2 ha (Koprivica et al., 2002). From this area, we have selected mountain pine (Pinus mugo) for this research.*

Key words: NP Sutjeska, mountain pine, anatomy.

1. INTRODUCTION

Mountain pine *Pinus mugo* Turr. (= *P. montana* Mill.; *P. mughus* Scopoli) is a shrubby bush or a smaller tree up to the height of 10 m. Its communities occupy large areas in the highest altitudinal zones of NP Sutjeska. An exception is its variety hook pine (*P. mugo* Turr. var. *rostrata* Hooper), which can reach the height of up to 20 m. As it is a part of the genetic growing stock of the European forest species, of relatively large distribution and having a protection character, there is a special interest in the comprehensive research of this species (Vilotić *et al*., 1997; Stevanović *et al*., 2005). Mountain pine differs from other species in the genus *Pinus* L. (Vilotić, 2000).by the anatomic structure of wood (narrow growth rings up to 1mm, narrow tracheids up to 20 μm).

There are many varieties and horticultural forms of mountain pine which differ by the number of resin channels from *P. montana* (two resin channels on the needle cross section) (Vidaković, 1982).

The aim of our research was to determine the variety of mountain pine growing in the area of NP "Sutjeska" locality Maglić, based on the morpho-anatomic structure of the needles and morphological characters of the cones.

2. MATERIAL AND METHOD

The mountain pine needles were collected in NP "Sutjeska" at the locality Maglić, thanks to the colleagues from the Faculty of Forestry of Banja Luka. The histological preparations of the mountain pine needles were made as microtome temporary and permanent preparations within the course of Forest Botany and Wood Anatomy. The variety was determined based on the keys for the subclassification of the genus *Pinus* L.; the Key for the determination of the species (Vidaković, 1982), and based on the comparative survey of the species characteristics (Debazac, F.E., 1967). The quantitative characters of the needles and cones were analysed biometrically, i.e.

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the boundary values were determined, mean value, standard deviation, variation coefficient and their errors.

3. RESULTS WITH DISCUSSION

Based on the anatomic structure of the needles (primarily the number of resin channels) and morphologic description of the cones (symmetric cones and the position and the description of the apophysis), there are several varieties of mountain pine: a) var. *unicinata* Ram. with two subvar.: *rostrata* Ant. and *rotundeta* Ant.; b) var. *pumilo* Haenke and c) var. *mughus* Scop. (Vidaković, 1982; Jovanović, 2000).

Based on the morpho-anatomic characteristics of the needles and morphologic characteristics of the cones (Figures 1 - 5; Table 1) and the source references (Vidaković, 1982; Debazac, F.E., 1967; Jovanović, 2000; Vilotić *et al.*, 1999, and others), it was concluded that the analysed needles from the area of NP "Sutjeska" locality Maglić, belong to *Pinus montana* var. *mughus* (Scop.) Willk.

The needles of the study mountain pine are dark-green, rigid, 2.4 cm (3.4 cm) 4.6 cm long, 1305 μm (1472 μm) 1530 μm wide, twisted, edges finely toothed, pointed.

The closed cones are 1.9 (2.7) 3.4 cm. long, 1.1 (1.4 cm) 1.8 cm wide symmetric, with a very short peduncle. The umbo is located in the middle of the scutellum and it ends with a point.

On the anatomic cross section of the needle (Figure 4) the abaxial and adaxial sides are differentiated. Below the epidermis, there is a layer of sclerenchyma cells. The mechanic cells (sclerenchyma cells) below the phloem of the vascular bundle are in 2-3 layers. In the mesophyll, near the epidermis there are up to 6 resin channels, with 6 to 10 epithelium cells, which surround them. In the central cylinder, there are two vascular bundles (it belongs to the sub-genus *Diploxylon*- Koehne) surrounded with endodermis composed of 48 cells.

Figure 1. Needles

Figure 2. Cone

Table 1: Morpho-anatomical characteristics of the needles

Needles length (mm)	Needles width (μm)	Needles thicknes (μm)	Width of the vascular bundle (μm)	Width of the resin channels (μm)	Number of resin channels	Number of epithelium cells	Number of layers of sclerenchyma cells
34.2	1472	875	172,5	66,4	4-6	6-10	2-3

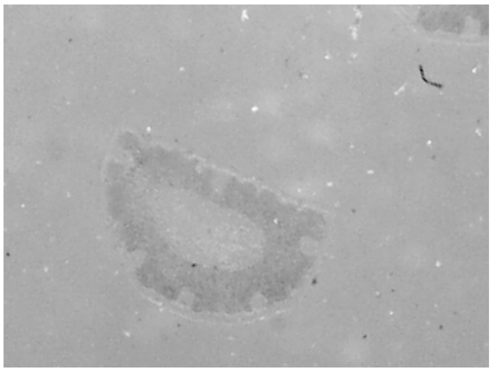

Figure 3. Needle cross section

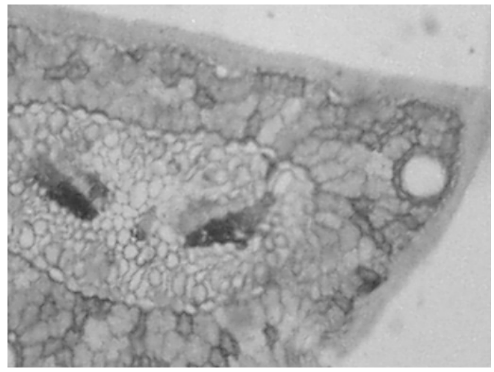

Figure 4. Central cylinder

Figure 5. Cross section of the stem

4. CONCLUSION

The mountain pine variety (*P. montana* var. *mughus* Scop.) from the locality Maglić, NP "Sutjeska", was determined based on characteristics of the needle anatomic structure and the morphological description of the cones.

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QUALITY AND GROWING FEATURES OF AUSTRIAN (BLACK) PINE (PINUS NIGRA ARN.) SEEDLINGS OF VARIOUS PRODUCTION TECHNOLOGIES

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Mare TERZISKA[3], Nasi GRAZHDANI[4]

Abstract: *In the paper quality and growth features of Austrian (Black) Pine seedlings of various production technologies are analyzed. The container seedlings have better quality of the shoot and root system. Their root system growing features are better than bare root seedlings. The linear regression models of mutual influence of some quality parameters are presented.*

Key words: Austrian (Black) Pine, container, bare root seedlings, quality, growth features

1. INTRODUCTION

Morphometrical and physiological seedling features investigation represents a base for better understanding of the process of their growth and development, and allows managing the production process through application of various biological-technological operations. In the R. Macedonia different investigations of container seedlings are executed (Popovski & Levkova 1975, Kolevska 1995, Terziska 2001), there are investigated effects of application of new nursery production technologies (Kolevska 1998, Grazhdani 2004), as well as development of Austrian Pine stands (Kolevska 1995, Trajkov et al. 2002).

Aim of this paper is to analyze deeper morphometrical features and correlation of Austrian Pine seedlings, produced by various technologies. Special attention is paid to container seedlings, which take considerable place in sylvicultural activities in Macedonia. There are no standards for estimation of their quality, which has been estimated empirically. The results of this investigation will find place in valorization of various seedlings types and future standardization of quality of container seedlings.

2. MATERIAL AND METHOD

In this investigation data from investigation of quality of Austrian Pine seedlings, produced by various technologies, were used (Kolevska 1995, Terziska 2002, Grazhdani 2004).

The seedlings were exposed to destructive analysis and measurement of: V (cm); D KV (mm); MND (g); number, length, weight of roots of I, II and III+IV degree separately; weight of CK (g) were executed.

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Table 1: Description of investigated seedling types

Seedling type	N	Description of seedling types
1.PP 1+0	5	KOS, PAPERPOT, type FH 508, 122 cm3;
2. JS 1+0	5	KOS, JUKOSAD, h=8 cm, +, 4.0 cm, 75 cm3
3. JS 1+0	5	KOS, JUKOSAD, h=8 cm, +, 4.0 cm, 75 cm3
4. PS 1+0	5	KOS, PIROSAD, h= 12 cm, + 5.0 cm, 160 cm3
5. SP 1+0	40	KOS, S-POT, 4.2x3.8x8.0 cm, 128 cm3 (multipot with 35 cells made from chromocarton
6. KL 1+0	10	KL
7. KL 1+0	40	KL
8. PP 2+0	30	KOS, PAPERPOT, type FH 508, 122 cm3;
9. JS 2+0	30	KOS, JUKOSAD, h=8 cm, +, 4.0 cm, 75 cm3
10. PS 2+0	30	KOS, PIROSAD, h=12 cm, + 5.0 cm, 160 cm3
11.KL 2+0	30	KL
12. KL 2+0	30	KL
13. KL/ 2+0	30	KL with cutted roots (in June 2+0)
14. PIK 1+1	30	KL transplanted in spring 1+0, at distance 10x10 cm

Explanation of the abbreviations in this paper:
N-number of analyzed seedlings, **KOS**–container seedlings, **KL**–bare root seedlings, **V**–height; **DKV**-root collar diameter; **ND**-shoot, **KS**–root system; **BK**-lateral roots; **CK**–central (tap) root; **MND**-weight of ND; **MKS**-weight of KS; **bk1r, bk2r, bk3r**-number of roots of I, II, III+IV de gree; **dk1r, dk2r, dk3r**-length of roots of I, II, III+IV degree; **mk1r, mk2r, mk3r**-weight of roots of I, II, III+IV degree

3. RESULTS AND DISSCUSION

In table 2, 4 and 5 features of ND and KS of Austrian Pine seedlings, as well as relations between some parameters are presented.

Even though in this investigation the analyzed seedlings types did not develop in identical conditions (data from several independent investigations were used), with executed analysis and comparison the nature of their growth and development can be deeper studied. KOS show better morphological quality, i.e. absolute values of parameters of ND, than KL seedlings. This is proved by many investigators (Popovski 1977, Stilinovic et al. 1980 and others). PS seedlings have the best KS and most favorable relations between ND and KS. Among KL seedling types, PIK (transplanted seedlings) have, in absolute values, the worst, and in relative values the best features.

It was investigated correlation coefficient (cc) between parameters of ND and KS of seedling type No. 3. (JS 1+0), No. 5 (SP 1+0), No. 7 (KL 1+0) and No. 14 (PIK). In table 3 cc of parameters with cc > 0.5, as well as elements of linear regression y=ax+b are shown. Existing of correlation between parameters of ND and KS is important for indirect estimation of seedling KS and its physiological quality.

Table 2: Morphometrical features of Austrian Pine seedlings and correlation between some parameters of ND and KS

Seedl. type	V	DKV	MND	MKS	V:DKV	V:MND	V:MKS	DKV: MND	DKV:MKS	MND: MKS
1.PP 1+0	9.8	2.2	0.5	0.3	4.4	20.8	39.1	4.7	8.9	1.9
2. JS 1+0	7.5	2.1	0.4	0.3	3.6	17.9	30.1	5.0	8.4	1.7
3. JS 1+0	13.1	2.0	0.8	0.3	6.6	16.9	42.1	2.5	6.4	2.5
4. PS 1+0	8.5	2.1	0.6	0.4	4.0	14.6	22.3	3.7	5.6	1.5
5.SP 1+0	11.2	1.9	0.6	0.3	5.9	19.6	39.9	3.3	6.8	2.0
6. KL 1+0	7.5	2.5	-	-	3.2	-	-	-	-	-
7. KL 1+0	6.6	1.2	0.2	0.1	5.7	41.2	65.9	7.3	11.6	1.6
8. PP 2+0	17.0	3.9	-	-	4.4	-	-	-	-	-
9. JS 2+0	9.9	2.8	-	-	3.5	-	-	-	-	-
10. PS 2+0	15.5	3.9	-	-	4.0	-	-	-	-	-
11.KL 2+0	14.0	3.8	-	-	3.7	-	-	-	-	-
12. KL 2+0	22.1	4.5	7.2	1.4	4.9	3.1	14.8	0.6	3.0	5.1
13. KL/ 2+0	19.6	4.1	4.0	1.1	4.8	4.9	18.7	1.0	3.9	3.8
14. PIK 1+1	9.3	3.3	1.9	1.3	2.8	4.8	7.1	1.7	2.5	1.5

Table 3: Correlation coefficient (r) and elements of linear regression y=ax+b

Seedl. type	DKV:MK1R		MND:BK2R		MND:MK1R		MND:MK2R	
	r		r		r		r	
	a	b	a	b	a	b	a	b
3. JS					0.80		0.61	
					0.02	0.12	0.02	0.07
5. SP					0.77		0.58	
					0.38	0.14	0.01	0.04
7. KL					0.68			
					0.00	0.17		
14. PIK	0.82		0.74					
	2.16	2.54	1.35	5.76				

Omi et al., (Sarvaš 2000) investigated that at Douglas Fir, cc between height growth and DKV, MKS and MND respectively reaches 0.25-0.43. Detailed analysis of growing features of KS (table 4) as the best pointed to PS, JS and SP seedlings, and between KL types – PIK.

Table 4: Parameters of root system (part I)

Seedl.type	BK - I degree			BK - II degree		
	bk1r	dk1r	mk1r	bk2r	dk2r	mk2r
1.PP 1+0	19	1146	-	56.4	1498	-
2. JS 1+0	18.2	1011	-	40.2	1592	-
3. JS 1+0	15.9	1036	0.12	23.6	985	0.07
4. PS 1+0	19.8	1445	-	101.4	3327	-
5.SP 1+0	12.4	854	0.12	23.9	721	0.04
6. KL 1+0	15.9	850	-	14.3	341	-
7. KL 1+0	10.3	271	0.02	2.9	21	-
8. PP 2+0	14.8	1097	-	41.9	1973	-
9. JS 2+0	25.3	1378	-	39.2	1707	-
10. PS 2+0	13	1560	-	56.9	2851	-
11.KL 2+0	17.6	1187	-	13	267	-
12. KL 2+0	13.3	749	0.23	11.7	222	0.02
13. KL/ 2+0	14.1	841	0.28	27.4	750	0.1
14. PIK 1+1	15.4	905	0.45	22.8	691	0.1

Table 4: Parameters of root system (part II)

Seedl.type	BK - III+IV deg.			BK-total I-IV deg.			weig. of CK	weight
	bk3r	dk3r	mk3r	No.	lenght	weight		of KS with CK
1.PP 1+0	17.2	373	-	92.6	3017	-	-	0.25
2. JS 1+0	25.4	728	-	83.8	3331	-	-	0.25
3. JS 1+0	13.7	331	0.03	53.2	2352	0.22	0.09	0.29
4. PS 1+0	64.8	1717	-	186	6489	-	-	0.38
5.SP 1+0	5.4	94	0.01	41.7	1670	0.17	0.11	0.28
6. KL 1+0	-	-	-	30.2	1191	-	-	-
7. KL 1+0	-	-	-	13.2	292		0.07	0.09
8. PP 2+0	27.4	839	-	84.1	3909	-	-	-
9. JS 2+0	32.6	1051	-	97.1	4136	-	-	-
10. PS 2+0	93.2	3265	-	163.1	7676	-	-	-
11.KL 2+0	-	-	-	30.6	1454	-	-	
12. KL 2+0	-	-	-	25	971	0.25	1.16	1.41
13. KL/ 2+0	-	-	-	41.5	1591	0.38	0.66	1.04
14. PIK 1+1	-	-	-	38.2	1597	0.55	0.77	1.32

Table 5: Growing features of root system of Austrian Pine seedlings

a.	PP 1+0	JS 1+0	JS 1+0	PS 1+0	SP 1+0	KL 1+0	KL 1+0	PP 2+0	JS 2+0	PS 2+0	KL 2+0	KL 2+0	KL/ 2+0	PIK 1+1
b.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
c.	20.5	21.7	29.9	10.6	29.7	52.6	78	17.6	26	8	57.5	53.2	34	40.3
d.	60.9	48	44.4	54.6	57.3	47.4	22	49.8	40.4	34.9	42.5	46.8	66	59.7
e.	18.6	30.3	25.7	34.8	13	-	-	32.6	33.6	57.1	-	-	-	-
f.	38	30.4	44	22.3	51.2	71.4	92.7	28	33.3	20.3	81.6	77.1	52.9	56.7
g.	49.7	47.8	41.9	51.3	43.2	28.6	7.3	50.5	41.3	37.2	18.4	22.9	47.1	43.3
h.	12.3	21.8	14.1	26.4	5.6	-	-	21.5	25.4	42.5	-	-	-	-
i.	-	-	54.5	-	70.6	-	100	-	-	-	-	92	73.7	81.8
j.	-	-	31.7	-	23.5	-	-	-	-	-	-	8	26.3	18.2
k.	-	-	13.6	-	5.9	-	-	-	-	-	-	-	-	-
l.	60.3	55.5	65.2	73	68.2	53.5	26.3	74.1	54.4	120	67.4	56.3	59.7	58.8
m.	26.6	39.6	41.7	32.8	30.2	23.8	7.3	47.1	43.5	50.1	20.5	19	27.4	30.3
n.	21.7	28.7	24.2	26.5	17.5	-	-	30.6	32.2	35	-	-	-	-
o.	-	-	0.012	-	0.014	-	0.007	-	-	-	-	0.031	0.033	0.05
p.	-	-	0.007	-	0.006	-	-	-	-	-	-	0.009	0.013	0.014
q.	-	-	0.009	-	0.011	-	-	-	-	-	-	-	-	-
r.	-	-	67.9		60.7	-	22.2	-	-	-	-	17.7	36.5	41.7
s.	-	-	32.1		39.3	-	77.8	-	-	-	-	82.3	63.5	58.3

Legend (I column):

a. Seedling type; **b.** No. of column; **c.** Participation of No of roots of I deg. in total No of roots in KS (%); **d.** Participation of No of roots of II deg. in total No of roots in KS (%); **e.** Participation of No of roots of III+IV deg. in total No of roots in KS (%); **f.** Participation of length of roots of I deg. in total length of roots in KS (%); **g.** Participation of length of roots of II deg. in total length of roots in KS (%); **h**. Participation of length of roots of III+IV deg. in total length of roots in KS (%); **i.** Participation of weight of roots of I deg. in total weight of roots in KS (%); **j.** Participation of weight of roots of II deg. in total weight of roots in KS (%); **k.** Participation of weight of roots of III+IV deg. in total weight of roots in KS (%); **l.** Average length of one root of I deg. (mm); **m.** Average length of one root of II deg. (mm); **n.** Average length of one root of III+IV deg. (mm); **o.** Average weight of 100 mm length of BK of I deg. (g); **p.** Average weight of 100 mm length of BK of II deg. (g); **q** Average weight of 100 mm length of BK of III deg. (g); **r.** Participation of weight of roots of I-IV deg. (without CK) in total weight of KS (%); **s.** Participation of weight of CK in total weight of KS (%);

4 CONCLUSIONS

= Container seedlings have better quality and growth features then bare root seedlings types, among container types, most favorable are PS, than SP and JS seedlings;

= among bare root seedlings types, most favorable shoot features have KL 2+0, while PIK have the best features of root system;

= there is correlation between some parameters of shoot and root system, which allows indirect estimation of physiological codition of the seedlings;

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EFFECTS OF DATE OF PREPARATION, DATE OF PLANTING AND STORAGE TYPE ON CUTTING ROOTING IN EURAMERICAN POPLAR

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Abstract: *In this work the influence of dates of cutting preparation (25th February and 20th March), dates of cutting planting (5th and 20th April) and types of storage (in trenches (4-12^{O}C) and in cooled chamber (2-4^{O}C)) on cutting rooting in two clones of euramerican poplars: Populus x euramericana cl. I-214 and Populus x euramericana cl. Pannonia. The placement of cutting on the shoot was also taken in consideration. Three characters of rooted cuttings were measured at the end of May: total number of first-order roots (TRN), height (SH) and number of leaves (LN) for dominant shoot. Results indicate the significant influence of examined treatments, as well as differences in reaction of examined clones on applied treatments. The effects of lower storage temperature and earlier planting dates were generally positive. The cuttings of clone Pannonia appeared more tolerable to storage in trenches. Significant interaction clone x treatment indicate the basis for the formation of cultivar technology, technology adjusted to specific needs of particular clone.*

Key words: cutting manipulation, cultivar technology

1. INTRODUCTION

Poplar hardwood cuttings have high rooting potential mostly because of possetion of preformed primordia in primary bark (Smit and Wareing, 1972). However, activation of primordia is complex process, influenced by many factors: genetic factors (within and between species), factors of variation within genotype (among and within plants) and numerous factors of environment (Pregitzer and Friend, 1996; Kovacevic, 2003). Hardwood cuttings are characterized by relatively high water content and metabolic activity. According to Nanda and Anand (1970) the changes in hormone content and rooting potential occurs during the period of dormancy, and these changes are more intense at the beginning of spring. Genotypes defers in dynamics of these changes, which is partially correlated with bud burst phenology (Kovacevic, 2003). According to Nanda and Anand (1970) and Fege and Brown (1984) duration and conditions of cutting storage influence physiological processes that are significant for primordia activation and root growth, especially carbohydrate and auxin metabolism.

The aim of this work is to exam the influence of dates of cutting preparation and planting, storage conditions and differences between examined clones in their reaction on these technological procedures, in course to obtain the basis for improvement of nursery production and breeding process of black poplars.

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2. MATERIAL AND METHODS

The experiment is performed in Experimental Estate of Institute for lowland forestry and environment near Novi Sad. Two euramerican poplar clones are examined: *Populus x euramericana cl.* I-214 and *Populus x euramericana cl.* Pannonia, clones that are widely used in poplar production in Serbia. Cuttings, 20 ± 2 cm long, were prepared in two dates: 20th February and 20th March 2005. and stored in two storing conditions: in trench (4 - 12°C) and cooled chamber (4 ± 1°C). Cutting were prepared from one-year old rooted cuttings, 200 - 250 cm in height, whose brittle top, less hardened part, was rejected. Five cuttings were prepared per stem, from five positions along the stem without brittle part: from basal part (b), from the first fourth form stem basis (m1), from the middle (m2), from the third fourth form stem basis (m3) and from the top (t). Cutting planting was performed in two dates: 5th April and 20th April 2005. The first date is in the middle, and the second at the end of usual period for poplar cutting planting in climatic conditions of Vojvodina.

Technological procedures were formed as combination of dates of cutting preparation, dates of cutting planting and storage conditions (Tab. 1).

Table 1. Examined technological procedures and their labels

Date of cutting preparation	Date of cutting planting	Storage conditions	
		Trench	Cooled chamber
20th Feb.	5th Apr.	T13	H13
20th Feb.	20th Apr.	T14	H14
20th Mar.	5th Apr.	T23	H23
20th Mar.	20th Apr.	T24	H24

Date of observation was 25th May 2005. The rooted cuttings were washed and three characters were measured: total number of first-order roots (TRN - transformed for statistical analysis by formula $\sqrt{X+1}$), height of dominant shoot (SH) and number of leaves on dominant shoot (LN). According to Okoro and Grace (1976) and Kovacevic (2003) rooted cuttings suffer the stress during spring (especially May), so this date was chosen differentiate the effect of examined sources of variation more precise. The data were processed by three-way ANOVA, fixed model:

$$X_{ijk} = \mu + a_i + b_j + c_k + ab_{ij} + bc_{jk} + ac_{ik} + abc_{ijk} + \varepsilon_{m(ijk)}$$

where μ stands for total average value, a - genotype effect, b - technological process effect, c - topophisis effect and ε - random effect. LSD-value is calculated by following formula:

$$LSD = t_{(\alpha, df_{ERR})} * \sqrt{\frac{2MS_{ERR}}{n}},$$

for α 0,05, where df_{ERR} stands for degree of freedom, MS_{ERR} - error square mean, and n - number of repetitions (sample size). The influence of sources of variation on total variation was evaluated contribution of their expected variances to the total variance (Kirk, 1968). In statistical analysis STATISTICA 6.0 program package was used (StatSoft Inc., 2001).

3. RESULTS AND DISCUSSION

Research work on this subject was rather rare especially in storage conditions (Kovacevic et al., 2002). However, our results show dominating influence of examined technological procedures and their interactions especially for number of roots (Tab. 2).

Table 2. Results of analysis of variance for measured characters

Sources of variation	df[1)]	Shoot height (SH)		Number of leaves (LN)		Number of roots (TRN)	
		F-value	$\sigma^2/\sigma_T^2(\%)^{2)}$	F-value	$\sigma^2/\sigma_T^2(\%)^{2)}$	F-value	$\sigma^2/\sigma_T^2(\%)^{2)}$
Clone(1)	1	26.44 **	8.66	30.11 **	11.03	11.16 **	2.79
Procedure(2)	7	19.90 **	25.72	22.15 **	32.05	38.11 **	40.79
Position(3)	4	16.46 **	13.15	5.15 **	3.94	20.73 **	13.56
1 x 2	7	2.74 **	4.73	2.22 *	3.70	3.71 **	5.95
1 x 3	4	2.42 *	2.42	0.83	0.00	1.38	0.52
2 x 3	28	1.63 *	4.30	1.39	2.98	1.18	0.97
1 x 2 x 3	28	1.01	0.19	1.05	0.82	1.22	2.43
Error	240		40.83		45.47		32.98

[1)] - Degrees of freedom; [2)] - Contribution of expected variance to the total variance

Most distin guishing a re differences b etween da tes o f c utting p lanting, w here val ues o f measured characters are usually more then 50% less if cuttings were planted in 20th April (Graf. 1). Because it is also the case for cuttings that were stored in cooled chamber negative influence of environment at the end of April on rooting of cutting planted in that time is clear.

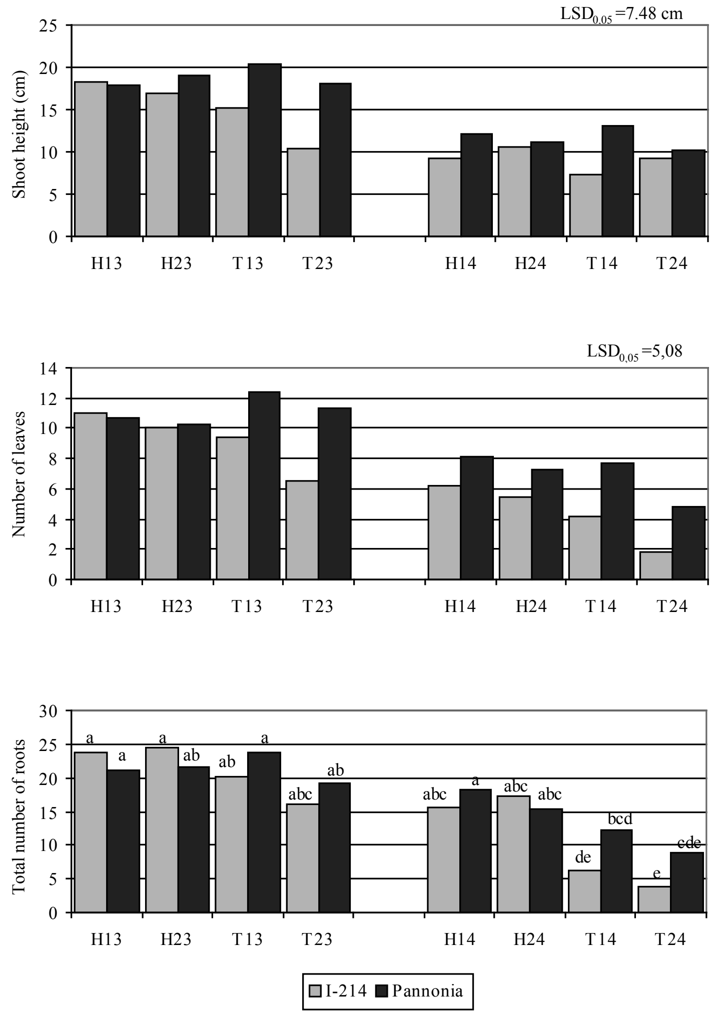
Differences between dates of cutting preparation are not so clear, but earlier date gave usually better results, especially if cuttings were stored in trenches.

Results of Kovacevic (2003) showed significant changes in rooting potential at the end of dormant period that defer among examined clones. We assume that the explanation is in higher degree of cutting dormancy that preserve the cutting from intensification of metabolism during the storage period, that, according to Nanda and Anand (1970), achieve negative effect on activation of primordia and cutting rooting generally.

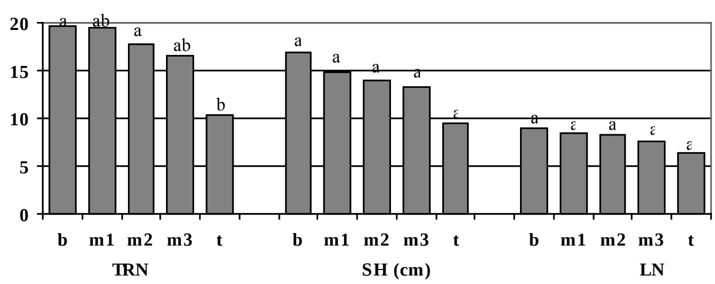
Beside b etter p erformance o f P annonia, t here w ere differences in r eaction o f exa mined clones o n t echnological p rocedure, esp ecially co ncerning st orage co nditions. A gain, P annonia achieved better p erformance a fter cutting sto rage in tr enches, but t here w ere no co nsiderable differences after t he st orage in co oled c hamber. N egative effect o f st orage in tr enches is in accordinance wi th Z ufa (1963), w hose r esults su pported p lanting of c uttings ne arly after their preparation, rather then their storage for a longer period. Clone I-214 wasless tolerable, especially after late planting date, while results for Pannonia suggest that there is possibility that storage in trenches co uld e ven stim ulate c utting ro oting (T13 vs. H13). W e assume t hat t he r eason is in fact that cuttings of Pannonia are more dormant (as it has later bud burst phenology. Dormancy prevent intensification of metabolism at low temperatures, but also allow activation of primordia (Nanda a nd Ana nd, 1970). S ignificant interactions genotype x p rocedure su ggest t he need f or cultivar technology, adjusted to specific cultivar needs. These interactions should also be taken in consideration in selection tests establishment.

The effects of cutting position on shoot (topophisis) were significant for every measured character, with clear decrease towards top cutting, which is in acco rdinance with re sults of Mu tibaric (1961). However, according to Kovacevic (2003), this trend was not so obvious in water culture. Only first-order interactions for shoot height appeared significant of all cutting position interactions.

Graph 1 Average values by clones and technological processes for measured characters



Graph 2. Average value for measured characters by cutting position)*



[*)] Character labels: TRN - Total number of roots, SH - Shoot height, LN - number of leaves
Lables for cutting position on shoot: b - basal, m1 - form first fourth form stem basis, s2 - from the middle, s3 - from the third forth form stem basis, t - top

Our results suggest considerable effect of examined factors and some of their interactions. They support earlier cutting preparation, cutting storage in cooled chambers and earlier cutting planting, as well as adjustment of nursery technology to specific characteristics of clone. They also give basis for selection tests improvement.

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PRELIMINARY RESULTS OF INVESTIGATION OF MORPHOLOGICAL TRAITS VARIATION OF WILD CHERRY (PRUNUS AVIUM L.) IN BOSNIA AND HERZEGOVINA

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Abstract: *Analysis of morphological traits was carried out for eleven populations of Prunus avium (wild cherry) sampled in their natural habitats in Bosnia and Herzegovina. For the morphometric analysis, sixteen variables (15 dimensional and 1 counted variable) were used to describe leaf and fruit variation. Each population comprised ten adult trees with 30 leaves and fruits measured per individual. The purpose of the study was to determine the level of intra- and interspecific variation. Morphological variation was assessed using standard descriptive statistic parameters, nonparametric and multivariate clustering methods. Significant differences were observed for each of the analysed characters be tween t he po pulations. The c luster a nalysis gen erated f our d istinct g roups o f w ild cherry populations based on unweighted pair-group average of Euclidean distances. However, the population "Sanski most" always formed a single group relative to others indicating on alochtonous origin of this accession. No clear geographic pattern was observed between the populations of wild cherry. Obtained results might be used in future programes for ex and in situ conservation methods of genetic resources of autochtonous wild cherry populations.*

Key words: wild cherry (*Prunus avium* L.), morphology, variation, conservation.

1. INTRODUCTION

Genus *Prunus* comprises about fifty species distributed in northern hemisphere. The most prominent species in European forests is represented by *Prunus avium*, *P. serotina* in America while many exotic congeners occurs in Asia. Although *P. avium* occurs is present in Africa and middle East, its most often occurences are present in Europe and the Balkan peninsula. Its high wood quality influenced the extensive use and partially contributed to disaperance of the species in its natural environments during the past. In Bosnia and Herzegovina forest fruit trees were protected by the low but during the last ten years many high value trees were cut. Thus genetic structure of natural populations have been seriously damaged in its environments.

The sweet cherry belongs to group of fast growing species, with production period of 40-60 years. The species is ecologically very plastic occuring from ripparian forests to subalpine beech forests, but it usually inhabits the fringes of forest vegetation. Its natural occurence is also tightly related to the seed dispersal mode mediated by the birds.

First investigations on the *P. avium* variability in BiH was conducted by Mikić (1991). The planty of natural populations was collected and half-sib progeny of 200 families was analysed but due to war activites the experimental plots were destroyed. During the last decade a nalysis of variability of morphological and genetic traits have been caried out at local scale (Ballian 2000, 2004; Mikić et al. 2004).

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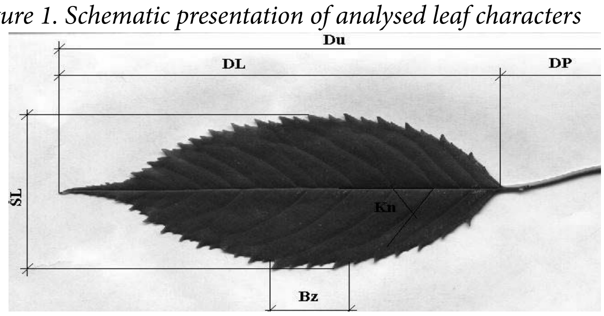
Data on morphological variablity of sweet cherry are scarce and there are some concerning the general information for certain traits. Existing data mostly deals with seed and floral characters (Ballian 2002), and also with fruit size that usually serves as discriminative character in taxonomy of the species.

In the paper we reported preliminary results of intra- and interpopulation variation of morphological characters using techniques of descriptive and multivariate statistic analysis. The main goal was assessment of level of phenotypic and genetic differentiation at local scale. The results of a such approach could be used in *ex situ* and *in situ* conservation activities of cherry genetic resources.

2. MATERIAL AND METHODS

Plant material was collected in 11 natural populations of the species: Kupres, Bos. Grahovo, Sanski Most, Turbe, Ključ, Trnovo, Sokolac, Konjic, Cazin, Kakanj, Ustikolina. Sampled populations present the main regions of distribution range in Bosnia and Herzegovina.

Figure 1. Schematic presentation of analysed leaf characters



In each population 10 individual trees were sampled. The leaves and fruits were collected from flowering shoots (30 per individual) from the upper part of solitary trees that was exposed according to south. In this way individual trees express the recent state of their phenotype and genotype, respectively (Trinajstić 1989; Trinajstić & Franjić 1993; Franjić 1993, 1994, 1994a, 1996). All collections were made during the august.

The fruits and leaves were measured by electronic calipper wit precision of 0.01 mm. Following characters were measured: Lp – fruit length; Sp – fruit width; Dp – fruit height. ; Ds- seed length; Ss- seed width; Ds – seed height; Dpe- petiole length; ss- petiole width; Du – total leaf length; DL- length of lamina; Sl- width of lamina at largest part of leaf; Kn – insertion angle of intercalary veins; Bz- teeth number at leaf blade/on 2cm surface; wl- width of lamina at 1cm distance beneath of leaf apex; wla- width of lamina 1cm above the base of leaf (Figure 1).

All stastistic analysis were carried out using software Statistica 6.0 for Windows as follows: the measures of descriptive statistics, parametric and nonparametric statistics and multivariate 'cluster' analysis.

3. RESULTS AND DISCUSSION

The results of statistic analysis are presented in Table 1. Generally observed variation of analysed characters are concordant with Herman (1971), Heike (1989) i Jovanović (2000).

Significant differences were observed for all traits analsyed among the populations and for interaction individul tree-population (df= 24,44, p< 0.01, Table 1). Also, significant differences

Table 1. Mean data of descriptive statistics and analysis of variance

Population		Traits															
		Fruit length		Fruit width		Fruit heigth		Seed length		Seed width		Seed heigth		Length of fruit petiolus		Width of fruit petiolus	
		x_s	s	x_s	s	x_s	s	x_s	s	x_s	s	x_s	s	x_s	s	x_s	s
Kupres		11,07	0,81	11,17	0,88	10,26	0,73	7,98	0,57	6,97	0,3	5,46	0,25	36,34	4,55	0,57	0,07
Bos.Grahovo		12,09	0,93	11,93	1,26	10,81	0,97	8,76	0,7	7,11	0,38	5,59	0,37	40,83	8,01	0,61	0,06
S. Most		11,89	1,19	12,81	1,57	11,29	1,22	7,96	0,59	6,76	0,48	5,44	0,4	42,18	6,92	0,58	0,06
Turbe		12,99	1,61	13,29	1,66	11,84	1,31	8,7	0,89	7,38	0,56	5,79	0,43	34,37	6,33	0,63	0,07
Kljuc		12,11	1,36	12,64	1,15	11,18	1,27	8,15	0,5	7,1	0,69	5,51	0,52	32,59	5,53	0,6	0,06
Trnovo		11,72	1,02	12,52	0,97	11,35	0,86	8,18	0,48	7,31	0,39	5,72	0,41	38,72	5,72	0,63	0,08
Sokolac		11,8	0,76	12,43	1,19	11,15	1,03	7,94	0,45	6,99	0,43	5,55	0,37	31,9	4,79	0,61	0,07
Konjic		12,16	0,84	12,44	1,02	11,14	0,94	8,05	0,63	6,63	0,54	5,15	0,37	34,02	5,62	0,61	0,06
Cazin		11,25	0,65	12,26	0,94	10,71	0,55	7,93	0,9	7,06	0,53	5,58	0,37	36,21	6,33	0,6	0,06
Kakanj		11,31	1,14	12,15	1,08	10,91	0,86	7,68	0,63	6,68	0,42	5,17	0,35	33,99	5,45	0,56	0,06
Ustikolina		12,47	0,86	12,92	1,31	11,89	1,2	8	0,5	7,09	0,74	5,54	0,63	34,5	5,99	0,59	0,06
An. varijanse		Df		Df		Df		Df		Df		Df		Df		Df	
Population	F	10	3,91	10	2,82	10	3,08	10	3,07	10	2,95	10	2,74	10	4,16	10	3,59
			0,01		0,01		0,01		0,01		0,01		0,01		0,01		0,01
Tree/Pop.	F	93	28,13	93	35,45	93	27,65	93	44,46	93	39	93	39,93	93	19,11	93	7,26
			0,01		0,01		0,01		0,01		0,01		0,01		0,01		0,01

Population		Traits															
		Petiolus length		Total leaf length		Length of lamina		Width of lamina		Insertion angle of ntercalary veins		Teeth number /2cm		Lamina width on 1cm distance ben		Lamina width on 1 cm above leaf base	
		x	s	x_s	s	x_s	s	x_s	s	x_s	s	x_s	s	x_s	s	x_s	s
Kupres		29,54	5,17	80,46	9,03	47,72	5,76	40,12	4,59	42,52	6,5	9,76	1,3	15,02	4,67	17,67	3,06
Bos.Grahovo		30	4,15	83,75	7,3	46,81	5,43	39,03	5,05	45,27	6,83	9,59	1,27	12,81	4,36	19,94	4,44
S. Most		30,88	5,94	83,8	11,37	45,62	7,47	45,34	6,84	48,69	6,84	10,34	1,35	15,82	4,32	24,08	4,78
Turbe		29,24	5,88	75,26	8,37	39,62	5,94	41,24	5,5	48,55	6,85	11,04	1,85	16,65	4,44	22,12	3,63
Kljuc		28,18	4,54	77,64	11,05	42,04	7,53	37,92	4,59	45,18	6,47	11,29	1,88	12,42	4,5	20,78	4,18
Trnovo		28,4	4,6	81,6	10,48	45,77	6,47	42,96	4,95	45,88	7,17	9,87	1,8	15,67	5,75	21,54	3,8
Sokolac		29,36	4,56	76,56	8,56	41,84	5,9	43,07	5,12	46,95	5,78	10,11	1,56	17,2	4,53	23,47	4,82
Konjic		30,29	3,56	81,24	7,08	46,4	5,04	40,29	5,45	43,05	7,05	10,13	1,43	10,94	4,95	20,15	3,99
Cazin		28,04	4,07	85,18	7,43	46,62	5,8	41,61	3,98	44,98	6,15	9,65	1,24	11,72	3,81	22,18	4,16
Kakanj		30,54	5,14	83,17	6,96	46,25	6,42	50,31	3,83	45,1	6,83	11,44	1,51	14,74	3,78	25,29	4,59
Ustikolina		27,03	3,4	77,57	8,38	42,79	6,38	40,73	5,15	46,63	6,19	9,82	1,74	15,31	5,71	21,45	5,21
ANOVA		Df		Df		Df		Df		Df		Df		Df		Df	
Pop.	F	10	1,11	10	2,75	10	3,79	10	8,05	10	2,33	10	3,81	10	3,61	10	5,25
			0,36		0,01		0,01		0,01		0,02		0,01		0,01		0,01
Stablo/ Pop.	F	93	18,02	93	14,28	93	11,65	93	18,78	93	7,93	93	12,82	93	15,89	93	11,92
			0,01		0,01		0,01		0,01		0,01		0,01		0,01		0,01

were recorded for tree-population interactions between all populations analysed (df= 6,46, p< 0.01, Table 1).

Cluster analysis based on Euclidean distances

Cluster analysis was carried out using four different methods but among-population differentiation was highest when Euclidean distance matrix was used. Thus we present only the results of cluster based on Euclidean distances (Figure 2).

- Complete linkage distances of analysed traits

Based on complete linkage distances of morphological traits, four clusters were generated (Figure 2). It is obvious that population Sanski most presents a single group that is not related to the others. Such a distinct position in the cluster analysis could imply to a specific origin of the population that has been introduced in this region during the past. Distinct features of this accession was also obvious from the results of descriptive analysis (Table 1).

- Single linkage distances of analysed traits

The method of single linkage distance of analysed traits reconfirmed the position of Sanski most population. However in relation to previous analysis five clusters were generated this time. The accessions Kakanj and Turbe formed a distinct cluster supposing a weak introgression of nonautochtonous material in these populations.

- Average linkage distances of the populations

Based on average linkage distances only populations Turbe and Sanski most formed distinct groups while the others had the same position in the cluster tree (Figure 2).

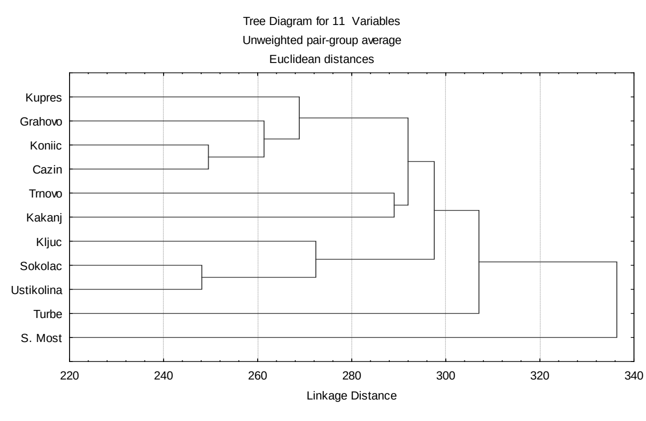
- Ward's method

By employing Ward's method in groups discrimination four clusters were gained, but the accession Sanski most formed a distinct group relative to other populations.

There is no specific geographic pattern for discrimination of sweet cherry populations. The clustering of populations could not be explained by any single factor, but rather dispersal mode by the birds and other animals and anthropogenic influence as well.

In previous study on morphometric variation of *P. avium* a weak differentiation was also observed (Ballian 2002). Molecular analysis revealed a weak differentiation between the populations of sweet cherry in this part of the range (Ballian 2004). Many factors such as ancestral polymorphism, postglacial recolonization from the Balkan refugia could contribute to absence of differentiation patterns. Possible reasons lie in devolepmental factors and adaptation processes to contrasting environments. Although precise analysis of morphological variation may give a pattern of differentiation to specific factors at large scale investigations, the samples collected from limited geographic area might not reflect the same pattern (Franjić 1996).

Figure 2. Tree diagram of sweet cherry populations based on complete linkage of Euclidean distances



4. CONCLUSIONS

Preliminary analysis of 16 morphological traits of cherry populations revealed the existence of significant differences between the populations. Observed variation is discontinous in this part of the species' range. The results could be applied in local and regional species' differentiation at population level.

Accession Sanski most shows a specific pattern of morphometric variation indicating on alochtonous origin of the population.

If molecular characterization is not available morphometric analysis could be applied to determinate and identify seed and reproduction material. The promissing results lie in combined molecular and morphometric analysis in the future. In this way selection and conservation programmes may be succesfully obtainable for many forest tree species.

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SEED QUALITY AS THE PRIMARY PARAMETER OF AUSTRIAN PINE SEED STANDS IN SERBIA

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Abstract: *The results of multiannual laboratory tests of Austrian pine (Pinus nigra Arn.) seeds from seed stands in Serbia are presented. The test results and their comparison are the base for the closer study of the following:*

- difference in morphological characters and germination dynamics of the seeds produced in seed stands,
- variability of seed quality inter- and intra- different seed stands,
- variability of germination percentage in the long-term period,
- comparison of seed quality collected within a seed stand and the seed collected along the margin of the seed stand.

Key words: Austrian pine, populations, seed quality, variation

1. INTRODUCTION

Austrian pine excels as one of the most significant conifer species, not only because it forms pure and mixed natural populations, of high economic and ecological value, but also because it is very suitable for afforestation and because it is very much used to that purpose (Mataruga, 2003). For the above reasons, the interest of tree breeders is directed to the study of population variability of this species and the possibility of its directed utilisation.

Every good program and concept in afforestation begins with the seeds. The higher efficiency is achieved by the selection of good-quality planting material which originates from the selected seeds from the recognized seed stands. The harmonised program of seed services, producers and selectionists is aimed at the conservation and improvement of the genetic potential of autochthonous tree species biodiversity (Lavadinović, Isajev, 2001).

The selection of species in afforestation is equally important as the identification of the localities and provenances, so as to eliminate the ecological impacts. Aiming at the selection of the superior provenances, genetic characteristics, and the differentiations of the indigenous species of conifers, the analysis of seed quality has been intensively studied during the last years. At the Institute of Forestry, seed analysis has been performed during a long time period, and this paper is focused on the last seven years of the research of morphologic and physiologic parameters of Austrian pine seeds.

2.MATERIAL AND METHOD

Aiming at the study of intra-provenance variation, as the base for the selection of seed zones in Serbia, the Institute of Forestry in Belgrade has been performing the continued test methods for the determination of seed quality, for several decades. The first analyses of seed quality started

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in 1948, which was the base of the substantial research experience in this field. The results of the previous work on the research of seeds during the past period are numerous valuable data which are very important, representing a continued and long-term research.

A greater efficiency of such research can be achieved by the adequate selection of good-quality planting material, which originates from the selected seeds from the recognized seed stands. The morphological and physiological parameters of Austrian pine seeds were researched in accordance with the ISTA Standard and Guidelines for forest coniferous species.

During the seven-year period, the seeds were analysed in two seed stands (Table 3). The seeds were collected in seed years and tested by standard method in the conditions determined by the standard. The seeds for this analysis of seed quality were provided by the producer.

The seed year in Austrian pine seed stands in Serbia made it possible last year to collect the seeds from all six localities and in this way all Austrian pine seed stands were represented in the test (Table 1). This made it possible to compare the data and to draw the conclusions which will contribute to the development of seed science and technology in Serbia, as the essential link in the chain of seed science, nursery and afforestation.

3. RESULTS WITH DISCUSSION

Based on the legal regulations that the vital and seed trees should not be felled within the seed stands, and based on the previous experience that it is only a selected and representative part of the forest in which its basic function of seed production is realised, which by quality can also be found within the forest and also along the margin of the seed stands, ten trees were felled on the very margin of the seed stand (Table 1). The selected trees were the representatives of good-quality trees in the seed stand.

The cones were collected in the period of two weeks from all six localities. The seeds were extracted by the regular procedure of seed extraction in the same conditions. By the random sample system, the necessary amount of seeds was selected, which was then tested by the standard method.

Table 1 shows that the percentages of seed yield in all six localities were the similar values, with the difference of maximum 9%. The study results indicate that in all the analysed seed stands, there is an inter-population variation of yield quality, which is clearly visible in this case.

Table 1. Percentage of seed yield in the six seed stands of Austrian pine in Serbia, in seed year 2005

Number of seed stands	Locality of seed stands	Germination percentage
S 01.03.02.03 Austrian pine (*Pinus nigra* Arn.)	MU"Goč-Gvozdac" Comp. 92b. Faculty of Forestry -Belgrade-Goč	**90%**
S 01.03.02.04 Austrian pine (*Pinus nigra* Arn.)	MU "Studenica-Polumir"17c, 26a. FE "Stolovi" Kraljevo	**89%**
S 01.03.02.07 Austrian pine (*Pinus nigra* Arn.)	MU "Šargan" 22 b. FE "Užice" Užice	**92.5%**
S 01.03.02.08 Austrian pine (*Pinus nigra* Arn.)	MU "Divan-Breze" 27a. FE "Forestry" Raška	**83.9%**
S 01.03.02.14 Austrian pine (*Pinus nigra* Arn.).	MU"Divan-Lokva" 21a FE "Forestry" Raška	**91%**
S 01.03.02.15 Austrian pine (*Pinus nigra* Arn.)	MU "Crni Vrh Ljeskovac" 69 c. FE "Prijepolje" Prijepolje	**91%**

The comparison of the quality of seed yield collected by the researchers on the margin of the seed stands and the quality of seed yield collected in the seed stand by the producers - SE "Srbijašume" (Table 2), confirms the initial hypothesis that the differences will be negligible. This surely indicates that the results of the germination percentage in Table 2 are the relevant indicators of yield quality in the seed stands with a low difference which can be considered as irrelevant in practice.

Table 2. Variation of the seed yield percentage obtained by SE "Srbijašume" and the seeds collected in the field by the researchers

	SE "Srbijašume"	Researchers
Pinus nigra S 01.03.02.07 FE Užice	**89.5%**	**92.5%**
Pinus nigra S 01.03.02.04 FE Kraljevo	**88.5%**	**89%**

Table 3 presents the seven-year survey of the research of seed quality in two Austrian pine seed stands in the full seed years, which occurred in the cycles of three years. The variation of the seed-yield percentage is concluded based on this small sample and based on the previous experiences with other species. The cause of the change of seed yield quality should be assigned to the variation of climate characteristics in the study years.

Table 3. The percentage of seed yield and its variation in the period of 7 years

	1999	2000	2001	2002	2003	2004	2005
Pinus nigra S 01.03.02.07 FE Užice	71.2 %	-	-	**74.8%**	-	-	**89.5%**
Pinus nigra S 01.03.02.04 FE Kraljevo	**71.2%**	-	-	**71.5 %**	-	-	**88.5%**

4. CONCLUSION

The high genetic potential, the disjunctive range, the high genetic variation as well as the plasticity and the possibility of thriving on the most unfavourable terrains, and a series of other characteristics, made Austrian pine a very significant species in all fields of forestry.

The testing of seed quality in laboratory conditions is necessary for the calculation of production planning of the reproductive material for afforestation purposes. The study of seed quality, as well as of its status at the moment, and the changes in time, present the base for the studious and comprehensive monitoring of other factors which affect the seed quality.

Based on the research, it can be concluded that Austrian pine has a pronounced inter-population variation of seed yield quality within the same year and between different years. The variation can be used as the base for the realisation of the programme of seed stand designation and for the establishment of the seed zones based on the Austrian pine seed quality, in the aim of selecting the superior phenotypes and genotypes in Serbia (Isajev *et al.*, 2001).

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PROPAGATION OF *CHIMONATHUS PRAECOX* L. BY CUTTINGS

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Abstract: *Chimonanthus praecox L. is an ornamental tree species originating from China. Its yellow coloured, fragrant flowers appear during winter, usually from November till February. Propagation and introduction of this species would increase the diversity of ornamental trees in our parks. Propagation was performed using cuttings of top branches containing one or two internodes. Two propagation methods were employed. In the first cuttings were collected 4 times (Jun 21st, July 8th and 24th and August 8th) and their basal ends were briefly dipped in powder containing 0.8% IBA. Cuttings were placed in a glasshouse and rooting parameters were scored after 6 weeks. The highest rooting percentage (37.3%) and the best development of root system was obtained in cuttings collected on July 24th. In the second approach cuttings were immersed 24 hours in solution containing 20 or50 mgl^{-1} IBA. Cuttings were planted on Jun the 7th. Rooting percentage in cuttings treated with 20 mgl^{-1} IBA was 11.1%, and 23.9% in cuttings treated with 50 mgl^{-1}.*

Key words: *Chimonanthus praecox L.*, rooting, cuttings, IBA.

1. INTRODUCTION

Chimonathus praecox L. (wintersweet) is an ornamental tree specie originating from China, belongs to the family Calycanthaceae which grows as a shrub or small tree up to 3m high. English name indicates a plant which is used in horticulture as an ornamental species. Flowers appear during winter usually from November till February depending on climate circumstances. Flowers are yellow, melliferous and intensively fragrant. This species grows in a climate zone 7-9 and it can survive shorter frost periods down to -18^{0}C. *C. praecox* grows the best on the loose, fresh and clayey soil (Šilić, 1990; Vukićević, 1987). Taxons recognised within the species are; *C.praecox* "Grandiflorus" with 4-5 cm long bright yellow flowers and clearly shown chestnut ornament in the middle; *C.praecox* var. luteus (syn "concolor") with bright lancet leaves 12cm length, waxy yellow and highly aromatic flowers and *C.praecox* "Margaret Best" which is not enough explored.

Besides its exceptional characteristics (flowering season and aromatic flowers) Wintersweet is a rare species in our parks and green areas. Possible reason for this situation is lack of data on commercial propagation of this species (Hartmann et al., 1990; Doran, 1941; Whitcomb, 1978). Most of publications, dedicated to the propagation of this specie underline generative reproduction as a basic propagation method (Lamb et al., 1975; Cheers, 1999; Šilić, 1990). Seed propagation taking in account minor number of inner species taxons, can be good aproach in the creation of new varieties. Reproductive phase starts later and this is the main reason for the need of an alternative method for vegetative propagation.

Flattening is the main method of vegetative propagation (Macdonald, 1986), since the rooting percentage of green cuttings is low (Lamb et al., 1975).

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The rooting success of Wintersweet cuttings is highly variable and it depends on the level of hardyness (Kruessmann, 1981; Lamb and Kelly, 1975; Bartels, 1982). The rooting of young softwood cuttings was also successful in the other species and interspecies taxons. (Kelly, 1992). Cross section of annual soft wood cuttings indicates early appereance of sclerenchim, which is a mechanical barrier for extention of root primordia. (Beakbane, 1969; Kelly, 1992). Second reason for the use of green cuttings are higher levels of endogenous phytochormones which are highest just before flowering. Afterwards their levels are decreasing and presence of inhibitors is increasing.

Wintersweet is a species in which propagation by standard methods of vegetative propagation is difficult. In this work present two different procedures for propagation by cuttings.

2. MATERIAL AND METHODS

Cuttings were collected from a tree growing in the Arborethum of the Faculty of Forestry, Belgrade. Experiments were conducted as two separate sets. The first set comprised 4 series of cuttings sampled in a period ranging from June till August 2001 (21st June; 8th and 24th July and 8th August). In the first term sprigs (sprouts) had fully developed leaves and soft tips. At the time of second sampling cuttings showed initial signs of hardyness. In third serial cuttings were lignified. In the fourth serial cuttings had completely formed terminal winter buds. Cutting swhich consisting of one or two internodes were collected early in the morning.

Cuttings were placed in Benfugin (Galenika, Zemun) solution (0.5%) for 30 min and then the basal ends of cuttings (2 cm) were dipped in rooting powder containing (0.8%) IBA.

To decrease transpiration upper leaves were halved and lower leaves were removed. Planting substrate contained a 3:1 mixture of peat and sand. Watering was repeated daily, and each 7-10 days cuttings were treated with Benfugin 0.5%. Cuttings were protected with transparent foil under which temperature varied from 20-35^{0}C. Six weeks after planting cuttings were examined and the main rooting parameters (rooting percentage, number and length of roots) were measured.

The second experimental set consisted of cuttings collected on 07th June 2006. Bases of cuttings were were dipped for 24 hours in water solutions containing 20 or 50 mgl^{-1} IBA. Cutings were planted and measured in the same way as the first set treated in powdered IBA.

3. RESULTS AND DISCUSSION

Results of the first experiment are showed in Table 1. percentage of rooting is relatively low in all four treatments. Cuttings from the control group which were not treated with IBA did not root.

Table 1. Rooting of cuttings from 4 treatments comprising the first experimental set after 42 days. Means ± SE, n = 158-231. Within each colum means followed by the same letter were not significantly different according to LSD multipe range test at P ≥ 0.05.

Date	Necrotic cuttings (%)	Non rooting (%)	Rooting (%)	No. of roots per rooted cutting	Total length of all roots ±SE (cm)	Longest roots ± SE (cm)	Length of the longest root ± SE (cm)
21.06.	11.7	62.3	26.0	5.16±0.6c	798.5	3.6±0.2b	6.1±0.4c
08.07.	57.9	25.3	16.8	3.43±0.5a	166.5	1.6±0.1 a	2.4±0.3a
24.07.	3.2	59.5	37.3	4.85±0.6c	1102.0	3.8±0.2b	7.4±0.6d
08.08.	21.3	62.6	16.1	3.94±0.8b	364.8	3.3±0.2b	4.9±0.6b

The highest rooting percentage of cuttings 37.3% was obtained in cuttings collected on 24th July and the lowest (16.1%) in cuttings collected on 8th August. Number of roots per rooted cutting varied from 3.43-5.16.

The mean number of roots per cutting varied from 3.43 to 5.16 and it was highest in youngest cuttings collected on 21. Jun. Thus it appears that there are two treatment times favourable for collecting cuttings, first at the end of June and the second and the end of July. Such decrease of rooting followed later by an increase was reported in other species *Acer platanoides*, *Malus* „Snowdrift" and *Aesqulus hippocastanum* (Chapman and Hoover, 1981). It should be noted that in cuttings collected on July the 8th there was a very high percentage of necrotic cutings which could be connected with a period of unusually high temperatures at the beginning of July. The effect of sezonal and physiological changes on rooting is mentioned by many authors (Tukey, 1979; Lanphear, 1964; Chapman and Hoover, 1981). Working with clones of *Pseudotsuga menziesii* Roberts, 1969 suggests that reduced rooting of cuttings in a certain period could be a consequence of unusualy high temperatures.

Figure 1. Rooting percentage of viable cuttings.

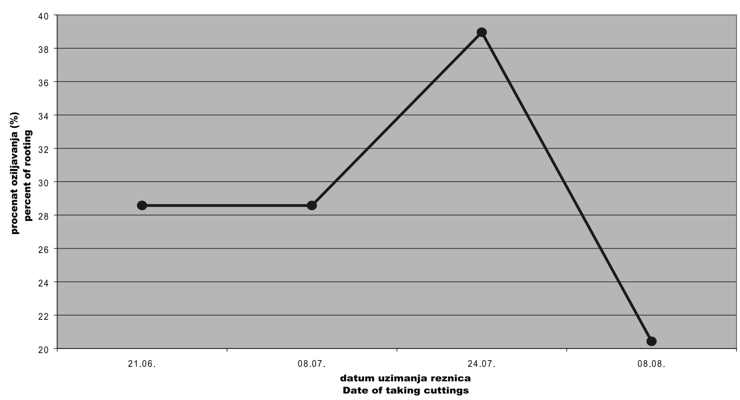

Figure 2. Rooted cuttings treated 24 h in IBA solution: 20 (left) and 50 mgl-1 (right); three months after auxin treatment

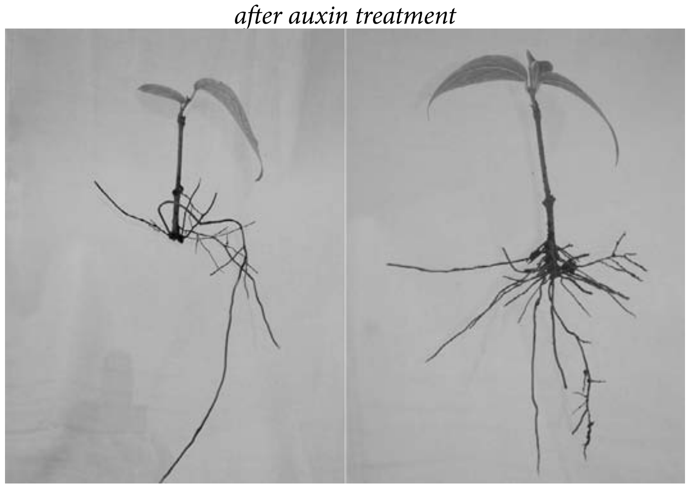

Figure 1. presents rooting in cuttings which were viable at the end of experimental treatments. Since cutting which perished from necrosis or those which dried were not taken into

account the results appear somewhat different. There is no apparent difference between the first two treatments, the third collecting performed on July the 24th provided highest rooting percentages and there was a significanty decrease in rooting ability of oldest cuttings. Now we can recommend end of July as optimal date for collecting cuttings.

Table 2. Rooting of cuttings treated for 24h in water solution of IBA, Measured after 42 days. Means ± SE, n = 32-46. Within each colum means followed by the same letter were not significantly different according to LSD multipe range test at P ≥ 0.05.

IBA mgl^{-1}	Necrotic cuttings (%)	Non rooting (%)	Rooting (%)	No. of roots per rooted cutting	Total length of all roots ±SE (cm)	Longest root ± SE (cm)	Length of the longest root ± SE (cm)
Contr	93.7	6.3	0	0a	0	0a	0a
20	53.3	35.5	11.1	4.0±1.4ab	47.7	2.6±0.5a	5.2±1.6b
50	60.1	15.2	23.9	5.2±1.1b	120.5	2.1±0.2a	4.5±0.6b

In the second set of experiments IBA was dissovled in water at concentrations 20 and 50 mgl^{-1} frequently used in other species (Kruessmann, 1981). Treatment with 50 mgl^{-1} IBA gave higher percentage of rooted cuttings (23.9 %), than the treatment with 20 mgl^{-1} IBA (11.1%) Table 2. The mean number of roots per rooted cutting also increased with IBA concentration. IBA (Figure 2.). However the root length was not significantly diferent in these two treatments. In some species rooting in liquid solution is a better choice since it can remove inhibitors from the cuttings (Grbić, 2004).

Our results indicate that high rooting percentages in Chimo nanthus could be obtained even with very young cuttings. Although these results are not jet sufficient for commercial propagation they indicate that vegetative propagation via soft wood cuttings may be soon feasible in *Chimonanthus praecox*. We would also like to point that in this species vegetative propagation can be obtained by techniques of *in vitro* culture (Kozomara et al., 2003.).

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CALCULATION OF THE CONIFER STEM VOLUME BY NEURAL NETWORKS

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Abstract: *An efficient method of calculation of the cumulative conifer stem volume based on artificial intelligence, i.e. on neural networks is developed. It is known that stem profile function is the basis of precise volume computing. The symmetric geometric figure whose volume approximates the true stem volume is obtained by the rotation of its profile function. The volume of this body, i.e. the stem, is obtained by the calculation of the value of the integral in which the subintegral function is the square of the profile function. Neural networks ensure a lower modelling error of conifer stem profile function than many classical methods. The improvement is from 20 to even 300% in many cases. In the case of calculation the cumulative conifer stem volume based on neural networks, instead of using the numerical method of integration, we can simply use the inner vector product. On the other hand, it is known that the application of the modified Brink's function enables the calculation of practically real volumes of conifer stems. Because of this, to verify the study results, they were compared to the cumulative volume obtained when the profile function corresponds to the modified Brink's function. The comparison of the volumes computed in the two previously mentioned ways is done by applying the regression analysis, that is by the definition of the regression line and the analysis of the obtained correlation coefficient* ***r****, as well as the standard error, SD. In the ideal case, the regression line must have the angle of 45^0 and has to start from the origin, and r and SD should evidently have the values 1.0 and 0.0 respectively. In the study case, the coefficients are: tg α=1.0038 and -0.00087, and the value of* ***r*** *and SD is 0.999997 and 0.001808.*

Key words: neural networks, stem profile function, stem volume, inner vector product, linear regression.

1. INTRODUCTION

An efficient procedure of volume calculation of both the standing and the felled trees is often necessary in forest practice. The first part of this paper deals with volume computing of individual trees i.e. measurement of individual trees, dendrometry in the narrow sense (Mirković and Banković, 1993). The second part presents the results that can be used in forest inventory, i.e. in stand measurement.

It is known that the oldest classical procedures of stem volume computing are based on the measurement of circumference, to reduce the errors introduced because of the asymmetry of the trees, i.e. the stems. However, the greatest number of methods for calculation of volume of felled trees and its parts is based on the mathematical (stereometric) formulas which mean the stem symmetry. This study also assumes the stem symmetry, as it is taken that the geometric figure which corresponds by volume to the observed stem can be obtained by the rotation of the stem profile function.

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The data on the attained volumes, increments, etc., are used both in the sustainable management of forest resources, i.e. in the sustainable utilisation of forest ecosystems, and in the calculation of the attained weight and biomass, (Dražić, *et al.*, 2005a) and (Dražić, *et al.*, 2005b).

An efficient and very precise procedure of stem volume computing, which is presented in this paper, is based on the application of artificial intelligence, i.e. neural networks

2. PROBLEM DEFINITION

It is known that volume can be calculated based on the defined stem profile function. In this aim, in the first step based on measured data, i.e. the sizes of the radii measured along the height of the standing tree, we determine with a procedure of optimisation (fitting), the function which approximates the function of the stem profile. By the rotation of the profile function around the central axis of the stem, a symmetric geometric figure is obtained and its volume approximates the volume of the true stem. In the second step, we obtain the volume by calculating the integral in which the subintegral function is the square of the stem profile function. It is clear that the analytic procedure can be applied in the case of integrability of the subintegral function, and when this is not the case, the numerical procedure of integration is applied.

This paper observes two approximations of the profile function i.e. two models of stem profile function. We deal with the application of the classical procedure, i.e. the application of modified Brink's function, and with the application of neural networks. As the application of modified Brink's function (MBF) has already been reported in several papers (Radonja *et al.*, 2005a), more attention will be focused to the application of neural networks (NN) in the modelling of the profile function.

3. MODEL OF PROFILE FUNCTION BASED ON NN

The model of profile function is most often based on the application of MBF (Brink and Gadow, 1986), (Riemer *et al*, 1995), which is very favourable in modelling the functions of this type. However, it was reported (Radonja *et al.*, 2005b) that the application of NN often ensures a considerably lower error of modelling. For this reason, the method based on the application of NN is preferred as an efficient method of generating the model with a low error of modelling.

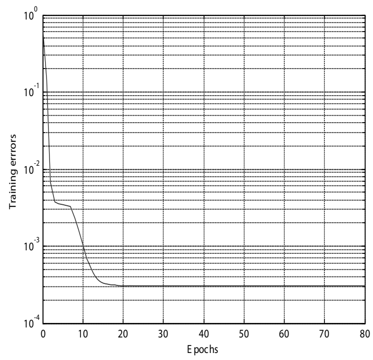
It is known that the best model for the observed data is obtained if a minimal number of neurons and neural network layers is used (Haykin, 1994). Practically, it is that number of neurons after whose reduction for one, there occurs a great increase of the modelling error. In our case, the optimal result is obtained if we have two ***tansig*** neurons in the hidden layer. The activating function of ***tansig*** neurons corresponds to the logistic sigmoid tangent hyperbolic function. Levenberg-Marquardt's algorithm (Beale, 1993) was used for the finding of the optimal coefficients of neural networks. The error of training, learning, NN gradually decreases and in the observed case the procedure of training is represented on Diagram 1. After normalisation, the obtained concrete model is presented in Diagram 2.

It is seen that the normalisation per x axis was with total tree height H and per y axis, with stem radius measured at the ground level.

The modelling error, i.e. the model deviation from the measured data, is presented in the following Diagram 3.

Table 1 presents the values of the standard modelling error, SD, for 7 spruces of different ages, from 12 to 127 years old, (Maunaga, 1995). The heights range from 5.65 to 29.7m and the halves of the diameter at breast height (D/2) range from 4.4 to 21.6cm. The values of the halves of diameter at breast height are given because profile function represents the dependence of the

Diagr.1. Procedure of training NN



Diagr. 2. Normalised model based on NN

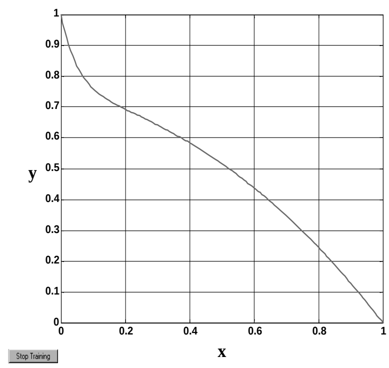
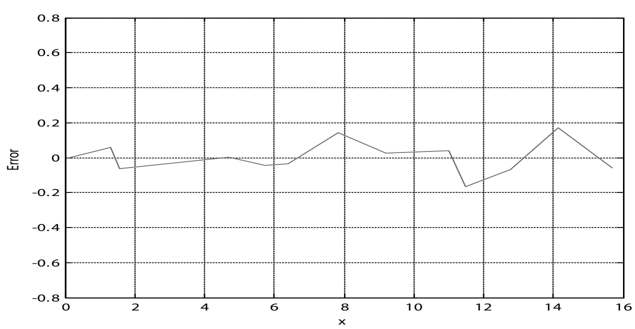


Diagram 3. Modelling error



radius on stem height (length). The data in Table 1 show that the trees are from the stands at the altitudes from 800 to 1300m. The comparison of the last two rows shows that SD in the case of NN is always lower than the SD in the profile function modelling by MBF. In the case of a 127-year old spruce, NN ensures a 3 times lower error, in a 68-year old spruce, the error is approximately twice lower, and the least reduction of SD is by about 10%.

Table 1.

Spruce [years]	127	103	68	53	39	30	12
H [m]	29.70	28.31	19.7	18.70	16.5	13.20	5.65
D/2 [cm]	21.6	16.2	12.1	10.4	9.0	6.7	4.4
altitude [m]	1300	1000	900	1160	1000	990	800
SD (MBF)[cm]	0.2908	0.1708	0.1565	0.0938	0.1072	0.0721	0.1355
SD (NN) [cm]	0.0992	0.1544	0.0871	0.0571	0.0897	0.0638	0.0793

4. CALCULATION OF VOLUME

In the case of MBF application, the square of the profile function is an integrable function, so it is possible to determine the analytic expression for the calculation of the (cumulative) stem volume (Radonja *et al.*, 2005a). The mentioned reference also presents the appropriate relation and several examples of the calculated volume. By using the above procedure, in this case the volumes of all 7 spruce trees were calculated, Table 2.

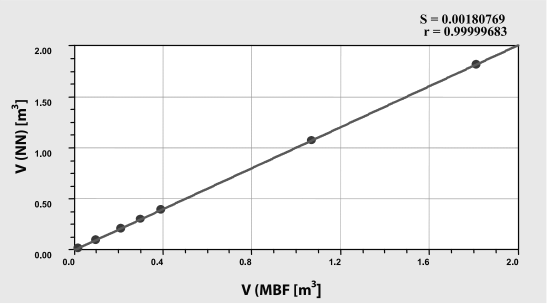
Table 2.

Spruce [years]	127	103	68	53	39	30	12
V MBF [m3]	1.8142	1.0721	0.3932	0.2997	0.2103	0.1002	0.0209
V NN [m3]	1.8210	1.0738	0.3966	0.2976	0.2102	0.0998	0.0205

When NN are applied in the procedure of approximation of the profile function, spruce volume can simply be calculated by using the inner vector product instead of the numerical integration. Table 2 shows that very similar results are obtained. The general conclusion is that the calculated volumes are probably closer to true volumes, taking into account the lower error of modelling.

Diagram 4 presents the comparison of the volumes calculated by regression analysis, i.e. by the generated linear regression for the available data.

Diagram 4. Volume based on NN and on the classical MBF procedure

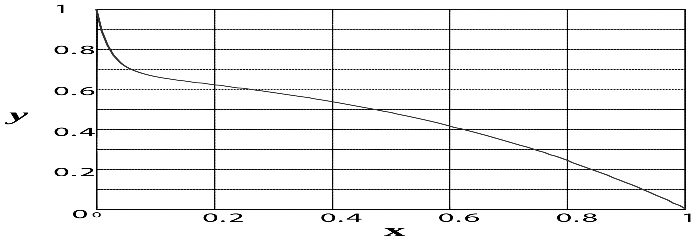


In the ideal case, it is necessary that regression line is at the angle of 45^0 and it has to start from the origin, and r and SD should evidently have the values 1.0 and 0.0 respectively. In the study case, the coefficients are: tg α=1.0038 and -0.00087, and the value of r and SD is 0.999997 and 0.001808.

5. GENERATING OF THE GENERAL MODEL

The calculation of the mean normalised model, if the adequate samples (objects) are selected, will produce the general (generalised) model, GM, of the observed process, for the defined region, Diagram 5.

Diagram 5. The general model of the process, based on NN



Any individual model can now be obtained, of course with an error, simply by the denormalisation of the *general model of the process* presented in Diagram 5. The denormalisation is performed so that each individual (denormalised) model passes through the characteristic point (x_0, y_0), (x_0 *breast height, 1.3m,* y_0 *radius at breast height)* and the final point *(H,0)*. Concrete, denormalisation per *x* axis is performed with *H,* and per *y* axis with y *(0)* where:

$$y(0) = y_0 / [y(x_0/H)]$$

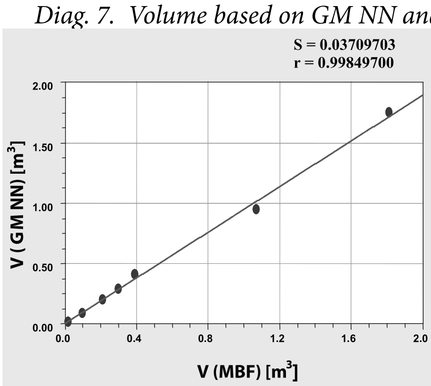
The value $y(x_0/H)$ is calculated based on the general model, Diagram 5. Based on the Diagram 5, which defines the normalised profile function, it is possible to calculate the volumes of the study spruces, by using the concrete values *D* and *H*. The calculated volumes are presented in Table 3.

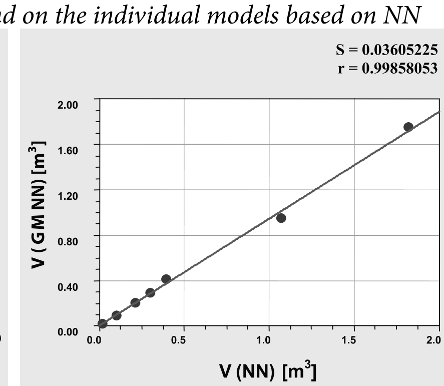
Table 3.

Spruce / [years]	127	103	68	53	39	30	12
V GM NN [m3]	1.7511	0.9521	0.4146	0.2907	0.2031	0.0852	0.0220

The volumes in Table 3 and the volumes in Table 2 were compared by regression analysis and the results are presented in Diagrams 6 and 7. Diagram 6 shows that the volumes calculated based on the GM presented in Diagram 5, do not deviate much from the volume calculated by the classical procedure and MBF, *SD= 0.0371* and ***r*** *= 0.9985*. Volume calculated based on GM deviates less from the volume calculated in the case when the profile function is approximated by NN, *SD= 0.0361* and ***r*** *= 0.9986,* Diagram 7. It can be seen that the regression lines are very approximately at the angle of 45^0, as tg**α** equals to 0.9454 and 0.9419. Also, they start approximately from the point of origin, as the translation along of ***y*** axis is 0.0053 and 0.0061 only.

Diag. 6. Volume based on GM NN and on the classical proced. based on MBF
Diag. 7. Volume based on GM NN and on the individual models based on NN





6. CONCLUSION

The approximation of the profile function by NN ensures a lower error of modelling than the classical procedure and the application of MBF, in all the analysed examples. The generated general model can be successfully applied for volume calculation in the study case, as the obtained regression lines are very approximately at the angle of 45^0.

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SECTION 2

BY AFFORESTATION, SERBIA WITHOUT BARE LANDS IN THE 21ST CENTURY

Milutin DRAŽIĆ, Nada VESELINOVIĆ, Mihailo RATKNIĆ[1], Ljubinko RAKONJAC[1]

Abstract: *During the turbulent historic events of social and demographic development, from the primitive activities of the first human settlements, agriculture and natural economy to the modern industrial era, man has been using the forest and its products for his survival and development, not taking care about the multiple ecological functions of forest ecosystems, until he was faced with the fact that deforestation endangered the survival on the planet.*

It is the last moment to stop further destruction of forest ecosystems and to start the reforestation of bare lands and the lands destroyed by erosion, which were covered with forests in the past, and to attempt the reestablishment of ecological balance of natural ecosystems on the planet, if it is not too late.

This paper analyses the status and the distribution of eroded bare lands with the consequences of deforestation and the long-term strategy of afforestation, to establish a relatively balanced ratio of natural ecosystems in our Republic, aiming at the conservation of the healthier environment.

Key words: percentage of forest cover, deforestation, erosion, skeletal bare lands, afforestation, ecology.

1. INTRODUCTION

The causes of deforestation on the planet are numerous. The destructive human impact on forests started with the discovery of fire and continued with the growth of human population, which was accompanied by the development of agriculture, and agricultural lands were created by forest clearing and destruction. Forests were simultaneously devastated for the production of biomass for heat energy, for building material and other purposes. The intensifying of agricultural development, and especially the development of animal husbandry, predominantly sheep-breeding after the introduction of sheep to Europe from the Asian Continent by the end of the ancient times, caused the creation of large areas under meadows and pastures in submontane regions, and they could have been created only by the intensified forest clearing on large spaces. The economic bloom of the Middle-Ages Serbian state (the Nemanjićs) was largely based on the development of mining and smelting, so this activity also caused deforestation.

Turbulent historic events and the wars on the Serbian territory also contributed to deforestation.

It is interesting to mention that the lowland terrains and foothills were demographically emptied, because the population under the Ottoman invasion fled to the shelters of inaccessible mountains where they cleared the forests just to survive, or they migrated to the surrounding countries (the Serbs' migration under Čarnojević). The deserted riparian and submontane lands were spontaneously covered with forests, so Serbia before the First Serbian Uprising was one of the European countries with the highest forest percentage of 70% and with only 3-4 inhabitants per 1km^2.

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After the liberation from the Ottomans, the demographic expansion advanced to the lands of Pomoravlje, Šumadija, Mačva, Podrinje and other districts, by the migration from the infertile mountainous regions of Montenegro and east Herzegovina, particularly after the Herzegovina Uprising (1876-1877). This was accompanied by drastic clearing and deforestation, which was further emphasised by the later economic crises and wars, so after the Second World War, the forest cover percentage dropped below 20%. This resulted in the huge areas of bare lands on which destructive erosion processes permanently removed the productive soil layer, threatening to change the once magnificent forest areas into lifeless stone deserts, if further erosion processes were not stopped by afforestation.

2. METHOD

Erosion processes were researched and erosion maps were constructed, with a short survey of the status and the consequences of erosion processes in Serbia.

After deforestation, the lands were used for agricultural production, so they are still filed as agricultural lands in cadastral documents, classified according to the site classes of the production potential.

As the lands in the hilly and mountainous regions are degraded by erosion, they are classified as agricultural lands form I to VIII site classes, depending on the degree of fertility i.e. erodibility. It was concluded that the more erodible areas with the marked skeletalness of the degraded soil layer, on the slopes above 15^{o}, as well as the agricultural erodible lands of the VI, VII and VIII site classes, cannot be transformed by agro-melioration measures to highly productive and economically rational agricultural lands. Consequently, if forest ecosystems are not established by afforestation, the destructive erosion processes will change these lands into inert stone deserts, with drastic ecological consequences,

Table 1 presents the review of the areas attacked by erosion per categories and sediment yield - VI, VII and VIII site classes, which should be afforested in the 21st century, with the necessary cadastre of the lands for afforestation and their delineation from the areas for agricultural production.

All the previous afforestation in Serbia was analytically surveyed with the evaluation of the success of the applied methods and technologies, and the sources of financing.

3. RESULTS

3.1. Erosion processes in Serbia and the consequences

Deforestation on large areas in hilly and mountainous regions, from the past till the modern ages, is the main cause of the occurrence and development of the destructive erosion, supported by the pronounced relief, inadequate methods of agricultural production and other unfavourable factors. It can be seen that in Serbia vast lands are degraded and turned into skeletal bare lands and infertile stone lands.

The research of erosion process and the construction of erosion map carried out by the Institute of Forestry (Lazarević, R. *et al.*) point to the ecological significance and economic consequences of erosion processes.

According to the erosion map, 76,354.43 km^2 or 86.39% of the total area of the Republic of Serbia are attacked by different intensities of erosion processes, while the zone of sediment accumulation covers 12,024.71 km^2 or 13.61%.

The area and sediment yield per erosion categories is as follows:

Table 1. Areas attacked by erosion and sediment yield per categories

Category	Area		Sediment yield	
	km^2	%	m^3	%
V – weak erosion	36,407.35	41.19%	3,890,949.42	10.44
IV – moderately weak	16,045.87	18.16%	8,041,404.46	21.59
III – medium erosion	11,198.38	12.67%	8,988,449.04	24.13
II – highly severe	11,675.83	13.21%	14,163,528.52	38.03
I – excessive	1,027.00	1.16%	2,165,643.30	5.81
weak erosion (V, IV)	52,453.22	59.35%	11,932,353.88	32.03
severe erosion (I, II, III)	23,901.12	27.04%	25,317,620.86	67.97
Total	**76,354.43**	**86.39**	**37,249,974.74**	**100.00**

Table 1 shows that severe erosion covers 27.04% of the total area of Serbia, with sediment yield 67.97% of the total sediment yield. Such destructive processes can be stopped only by the afforestation of eroded bare lands which are classified as agricultural lands of VI, VII and VIII site classes, partially also V site class on the slopes above 15^{o}.

Vojvodina is predominantly lowland area, mainly of the V category (weak erosion), so it can be concluded that in the remaining part of Serbia, together with Kosovo and Metohija, the stronger categories of erosion attack 40% of the total area.

The permanent and irreplaceable damage is caused by the fact that 9,350,764.78 m^3 or 172.46 m^3/km^2 of sediment from the territory of Serbia is transported by rivers to the seas, meaning the soil loss accounts for 25.10%. If the above sediment mass is converted into hectares, then the annual loss is 4,675.30 ha of the most fertile soil layer 20 cm thick. Starting from the fact that 2,390,121 hectares are attacked by severe erosion, the long-term projection predicts the afforestation of 1,350,000 hectares of the most endangered eroded skeletal bare lands in the hilly and mountainous region.

3.2. Degradation of agricultural soil as the consequence of destructive erosion processes

The destructive erosion processes are the main agents of degradation of agricultural land, which is manifested by the loss of the most fertile soil, frequently to the skeletal bedrock. The consequences are, inter alia, the reduction of the production potential (soil quality) of the eroded areas, primarily in hilly and mountainous regions.

Based on the data of the Republic Cadastre, the degraded agricultural soil is classified into site classes VI, VII and VIII, and they cannot be transformed into highly productive classes by any melioration agro-technical and agrochemical measures. They occupy the following areas:

Table 2. Agricultural land of VI-VIII class in Central Serbia

Land use	Cadastral site classes											
	VI			VII			VIII			Only		
	ha	%	%	ha	%	%	ha	%	%	ha	%	%
		54.9	49.0	228,520	51.2	35.2	101,885	46.1	15.8	648,416	52.0	100
		21.7	46.2	116,992	26.2	42.8	30,023	13.6	11.0	273034	21.9	100
Pasture		23.4	41.7	100,402	22.6	30.9	89,011	40.3	27.4	325,054	26.1	100
Total		100	46.5	445,914	100	35.8	220,919	100	17.7	246,504	100	100

Table 2 shows that the greatest part of VI, VII and VIII fertility classes are under farmland, which is understandable, because soil tillage supports the destructive effects of erosion.

The largest area of agricultural lands of VI-VIII site classes are situated in Central Serbia. In Vojvodina, the area of the above site classes is relatively small and it is mainly the saline soils, the sands, and the waterlogged soils. Table 2 does not present the data for the Province of Kosovo and Metohija, because the cadastral data are not available. However, we suppose that their share in the total agricultural land is considerable, because only in the area of Šarplaninske Župe (Sirinička, Gora, Opolje and Sredska), agricultural lands of VI to VIII classes amount to 32,841 ha, so it is supposed that in the entire Kosmet there are 70,000 hectares of the above site classes, i.e. in the entire Republic of Serbia, more than.300,000 ha of degraded agricultural land of VI-VIII site classes, on which erosion processes are underway and can be stopped only by afforestation.

3.3. Afforestation in Serbia to date

The first organised afforestation on the territory of the present-day Republic of Serbia started, in 1771 on the Sands Subotičko-Horgoška Peščara, during the Austro-Hungarian Monarchy. The pioneer works on afforestation and grassing of the Sands which occupied about 25,000 ha in Subotičko-Horgoška Peščara and about 50,000 ha in Deliblatska Peščara lasted for the following 100 years. In Vojvodina, about 15,000 ha of the Sands were afforested till the First World War. There are no precise data for the area of the Princedom of Serbia, because according to the archive files, the afforestation was not always measured in hectares, but in the quantities of consumed seeds or seedlings. Based on the available data, it is estimated that about 3,000 – 5,000 hectares were afforested on the Sands Ramsko-Golubačka Peščara and on the eroded bare lands in other hilly and mountainous areas till the First World War, under the full initiative of the local authorities and citizens who established various associations to stimulate the citizens to afforest the eroded bare lands. Pursuant to Article 28 of the first Forest Law in 1891, the forest fund was formed from the income of wood sold from the state forests, monetary fines based on the Forest Law, compensations for forest damage, taxes for the establishment of sawmills, charcoal kilns for potash and wood processing factories. The above Law in 1891 prescribed that the owners of the afforested lands were relieved from the taxes for the period of 20 years.

The new State after the First World War, the Kingdom of Serbs, Croats and Slovenians, later on named the Kingdom of Yugoslavia, was not too much engaged on the conservation of the existing forests, or in the stimulation of the afforestation of eroded bare lands.

Although the Forest Law in 1929 kept the provisions from the first Law in 1891, that the owners of the afforested lands were freed from the taxes for 20 years, it seems that this provision, because of the administrative-bureaucratic procedures, was not sufficiently stimulative and effective.

In addition to the above, it was concluded that one of the reasons of the delay in afforestation was the fact that the areas of the eroded bare lands which should have been afforested were not defined and identified.

For this reason, the Forest Law prescribed that the identification and mapping of bare lands for afforestation should be carried out within 10 years. The field work was completed in most districts till the Second World War. However, the field data were not processed on time and the cadastre of bare lands for afforestation and the general plans of afforestation were not drawn up. Unfortunately, all the collected data were destroyed during the War, which is a great loss, because even today we do not have the cadastre of bare lands for afforestation, and this obligation of the State was not kept in the post-war Forest Laws.

According to the available data, during the period between the two World Wars from 1919 to 1938 (there are no data for 1939/40), the following areas were afforested in Serbia:

Deliblatska Peščara	1,931 ha
Subotičko-Horgoška Peščara	1,324 ha
Ramsko-Golubačka Peščara	322 ha
Bare lands in other parts of Serbia	3,258 ha
Total	**6,862 ha**

which is average annual 343 hectares.

The composition of tree species used in afforestation (in %) is the following:

Black locust	75%
Austrian pine	8%
Ash	3%
Honey locust	3%
Other species	11%

Based on the above, black locust was the dominant species for afforestation in the mentioned period. The average success of afforestation accounted for 60%.

There are no authentic data on the chronology of deforestation from the beginning of the 19^{th} to the middle of the 20^{th} centuries, but it is a fact that Serbia during the above period from the country with the highest forest cover percentage in Europe became the country with a very low forest cover percentage, which is confirmed by the statistics in 1938, which reports that of the total area of Serbia (88,387 ha),forests occupy 17,763 ha or 20% (Jović, D. *et al.*, 1992) and that immediately after the Second World War forest cover percentage dropped to 19.3%. This was probably the lowest forest cover percentage in our country, because soon after the Second World War intensive afforestation of bare lands started with the participation of the "voluntary front" actions of the village population in the hilly and mountainous regions, which were surrounded with eroded bare lands (Zlatibor and other mountainous areas with large areas of bare lands).

3.4. Afforestation after the Second World War

The data on afforestation in Table 3 are the result of the research and analysis of archive materials for the period 1945-1954 and the data of the Federal and Republic Institute for Statistics for the period 1955-1990, while in the period 1990-2005 the analogous research was not performed.

Table 3 shows that the annual afforestation of eroded bare lands was relatively modest in the period 1945-1960. A significant increase occurred in the period 1961-1975. In the period 1976-1990 average annual afforestation was significantly increased to 15,930 ha.

The presented dynamics is mainly the result of the available financial means in forestry earmarked for infrastructural investments. Namely, in the period till the sixties, there was a Fund for the development of forestry (FUŠ), used for the financing of afforestation. The Fund was relatively small, predominantly formed from the accumulation from the forest economy, which was a low-accumulation economic branch. In the sixties, along with FUŠ, there was a General Investment Fund for the crediting of afforestation, mainly for the establishment of plantations and intensive cultures of fast-growing Euramerican poplar cultivars and clones, so during that Investment Fund, the establishment of plantations and intensive cultures of fast-growing poplars was more intensive.

The golden age of forestry, viewed through the infrastructural investments of irretrievable means, started by the establishment of the Republic and regional self-management interest

Table 3. Survey of afforestation after the Second World War

Period	Area	Total afforestation ha	Total afforestation			
			Broadleaves		Conifers	
			ha	%	ha	%
1945-1954 (10 years)	Central Serbia	41.856	25.770	62	16.086	38
	Vojvodina	20.980	18.000	86	2.980	14
	Kosmet	2.780	850	31	1.930	69
	Total Serbia	65.616	44.620	68	20.996	32
	Average annual	6.562	4.462	68	2.100	32
1955-1960 (6 years)	Central Serbia	19.636	10.105	53	9.531	47
	Vojvodina	19.103	17.002	89	2.101	11
	Kosmet	1.708	396	23	1.312	77
	Total Serbia		27.503	68	12.944	32
	Average annual		Total Serbia	40.447	2.157	32
1961-1975 (15 years)	Central Serbia	94.414	Average annual	6.741	38.312	41
	Vojvodina	49.091	46.292	94	2.799	6
	Kosmet	8.860	1.836	21	7.024	79
	Total Serbia	152.365	104.221	68	48.144	42
	Average annual	10.158	6.949	68	3.210	42
1976-1990 (15 years)	Central Serbia	180.604	36.987	20	143.617	80
	Vojvodina	36.993	35.113	95	1.880	5
	Kosmet	21.855	1.239	6	20.676	94
	Total Serbia	239.452	73.339	31	166.113	69
	Average annual	15.963	4.889	31	11.074	69
Total for period 1945-1990 (45 years)	Central Serbia	336.510	128.955	38	207.546	62
	Vojvodina	126.167	116.407	92	9.760	8
	Kosmet	35.203	4.321	12	30.882	88
	Total. Serbia	497.880	249.683	50	248.197	50
	Average annual	11.064	5.548	50	5.516	50

communities for forestry, within which accumulated financial extra-budgetary means from the contributions of all direct and indirect users of forest functions. These means were used for the financing of forest roads, reclamation of degraded forests, tending of young forests and so on, and the highest financial means were allocated for the afforestation of eroded bare lands in hilly and mountainous regions, such as Pešterska Visoravan, bare lands of Ibarska Klisura, mountainous massif of Vlasinska region and other bare lands in hilly and mountainous parts of Central Serbia, the Province of Kosmet and the flooded lowlands along the rivers.

Because of the demographic migrations from the rural areas, forestry was faced with the problem of the shortage of manpower for the realisation of the ambitious afforestation plans. The Institute of Forestry in Belgrade mastered the technology of seedling production, with protected roots in the peat substrate in special containers. Based on pilot-experiments, the Institute achieved the successful afforestation also during the vegetation period, during summer, so the self-management interest communities entrusted the Institute with the drawing up and operating of numerous afforestation projects (Dražić, M. *et al.*).

Team work consisting of specialised researchers was organised on the analysis and mapping of ecological environmental conditions and the categorisation of the lands relevant for the selection of tree species, application of the optimal methods and technologies of afforestation, taking into account the engagement of untrained manpower – pupils, students and young workers in the brigade work system – youth work actions of "settlement" type. As afforestation was performed during summer, the method and technologies of planting in "cells" were worked out in detail (Dražić, M.). Its main characteristic was that the cells were distributed in the "chess" position, so the surface atmospheric water was accepted and retained in the cell profile, which ensured the moisture during the dry period. Depending on the slope, the cell dimensions ranged from 40x40x30 cm to 60x40x30 cm. The soil was dug by the profile depth to 30 cm, without throwing out the soil particles, so as to keep the existing moisture, which is the main advantage of this method compared to digging the holes for planting. It also has a high ecological significance because it enables the free development of the root in the moist environment immediately after planting. From the cell profile, only the coarse skeleton is thrown out, and it is piled on the dry wall along the lower edge of the cell, which prevents the possible loss of soil particles after heavy rains and synchronically it keeps the water while it penetrates through the depth of the cell profile. To the same purpose, a counter grade is formed to the cell grade, its slope increases with the increase of the slope of the terrain and, as a rule, it ranges between 3 and 5°. Directly before the planting, the peat ball which surrounds the root in which the finest physiologically active roots are kept, is soaked in water to saturation. The plant is correctly vertically planted in the cells, which creates the conditions for the unobstructed continuation of the root growth, which can without obstacles be intimately connected to soil particles. The above preparation and planting of seedlings with water-saturated peat ball around the root, enables the plant to survive during the dry period without rain up to 30 days under summer temperatures, which makes it possible to plant during summer. This method was applied for the first time in the continental conditions of Europe, by the projects of the Institute of Forestry.

In the large areas of bare lands, such as Pešter, Ibarska Klisura and Vlasinska region, financed by SIZ for Forestry and supported by the State, relatively comfortable settlements were constructed for the accommodation of the brigadiers during the afforestation actions.

The brigades for afforestation were organised and formed by the youth and "Gorani" organisations, while the professional management of the afforestation was entrusted to the forest estates, i.e. forest administrations on whose territory afforestation was performed. The Institute of Forestry, with its research and professional staff, had the role of instruction and training. In a sense, the control role was also assigned to the professionals in the Self-management regional communities for forestry, managed by the Republic SIZ.

Mass afforestation actions were performed by the youth – pupil, student and worker youth brigades from all Republics of the former Yugoslavia. The actions lasted from 1978 to 1988.

At the beginning, there were sceptic opinions regarding the success of summer afforestation, even by forestry experts, but the results of plant survival by the application of the projected methods and technologies, even on the most severely eroded skeletal bare lands, were very successful, despite the fact that in some cases the project procedure was not completely respected from various reasons and despite the fact that the members of the youth brigades were not trained, they were without experience in afforestation and they were not accustomed to heavy physical work.

The research performed on extremely ecologically unfavourable terrains on the skeletal serpentine eroded bare lands of the Ibarska Klisura, has the following results:

Table 4. Seedling survival percentage

Conifers	Survival above 70% on 77% of the total afforested area
	Survival of 31-70% on 19.6% of the total afforested area
	Survival below 30% on 3.8% of the total afforested area
Broadleaves	Survival above 70% on 84% of the total afforested area
	Survival of 31-70% on 14% of the total afforested area
	Survival below 30% on 2% of the total afforested area

Broadleaf species were planted on the conserved sites and their percentage in the total afforested area was considerably modest.

It is exceptionally significant to emphasis that the huge spaces of the once eroded bare lands "Moon surfaces" are today magnificent anthropogenic forest ecosystems, of immeasurable ecological and economic values.

3.5. Long-term projection of further afforestation and the expected ecological-economic effects

In Serbia, destructive severe erosion (I to III categories) attacks more than 2,300,000 ha of bare lands in hilly and mountainous regions and, according to the Cadastre, the degraded agricultural lands from VI to VIII site class cover more than 1,340,000 ha. As in the above area the destructive erosion is still severe and it can be halted only by afforestation, the long-term strategy of forestry development plans the afforestation of bare lands on about 1,350,000 ha, which is confirmed by the Spatial Plan of development in Serbia.

By the realisation of the long-term projection of afforestation, the percentage of forest cover percentage should increase to about 42%, which is an approximately balanced ratio of forest, agricultural and other natural ecosystems in our country.

The ecological effects of the realisation of the long-term projection of afforestation are numerous, the most significant of which are:

- The destructive erosion processes, sediment transport and the loss of the most fertile part of agricultural soil will be halted or essentially mitigated;

- The landslides, destructive torrents and floods of the rivers with the headwaters in our country will be prevented and the floods of large transboundary rivers, where our influence is limited, will be mitigated, and flood control will be carried out by the construction of levees.

- The balanced hydrological regime of our local rivers and streams will be established by ensuring the stable watercourses without the presence of solid particles and without siltation of macro- and micro-storages for municipal water supply and hydro-accumulations for the production of electrical energy.

- Numerous scientists are warning that the biosphere is endangered and thus also the environment. For this reason, in international frameworks and within the UN there are attempts to reduce the use of natural resources, either renewable or non-renewable to sustainable development (Agenda 21, Rio), meaning that the resources may be used only to the degree of not endangering the future generations.

It is generally concluded that forest ecosystems are the ecological supports of the biosphere. They account for 33% of the entire production of organic mass. In the planetary proportions, they occupy 27% of the land, and the optimal percentage should be about 35%.

- Effect of forest ecosystems on oxygen and carbon cycling;

- The quantity of released oxygen and absorbed carbon is proportional to the productivity of phytomass in forest ecosystems;

- It is estimated that forests contain 400 to 500 milliard tons of fixed carbon in wood and other organs, and that is approximately 2/3 of the total reserves in the atmosphere;

- Forests are the most productive natural ecosystem regarding the production of biomass and accumulation of energy;

It is expected that by the afforestation of 1,350,000 ha, the new forest resources will reach the annual biomass production of average 4.5 tons per hectare, i.e. 6,075,000 tons annually, so if 1 ton of biomass fixes 1.82 tons of CO_2, and releases 1.39 tons of oxygen, this means that the new anthropogenic forests created by the afforestation of bare lands absorb annually 11,056,500 tons of CO_2 and release 8.462,470 tons of O_2 and thus, inter alia, have a positive effect on the balance of oxygen and carbon in the atmosphere and mitigate the greenhouse effect phenomenon in the atmosphere, i.e. global warming of our planet with potential catastrophic ecological consequences.

- Forest ecosystems neutralise and absorb numerous other gaseous pollutants from the atmosphere and are the most efficient purifiers of the air against sooth, dust and other solid particulates in the atmosphere. If 1 ha forests annually retains in its crowns 30-80 tons of solid particulates depending on the stage of development, canopy, tree species and other parameters, then the new forests on 1,350,000 ha annually retain 40,500,000 to 108,000,000 tons of solid particulates, which is an excellent contribution to a more healthy environment in forested landscapes.

- The new forest resources will, in addition to multiple positive ecological functions, also have excellent economic values, because annual production of more than 6 million tons of biomass will contribute to the development of the industry of mechanical and chemical processing of wood, which will cause the growth of economic standard, and a considerable percentage of the produced biomass will be used for energy.

4. CONCLUSION

Huge areas of agricultural land in hilly and mountainous regions, which were created by forest clearing in the past, were turned into skeletal eroded bare lands, with the tendency of transformation onto inert stone deserts, if they are not afforested.

Today, the above areas are still categorised as agricultural lands of VI to VIII cadastral site classes. They cannot be transformed into highly productive areas for agricultural production by any agro-melioration measures.

The afforestation of eroded bare lands on about 1,350,000 ha is predicted by the long-term projection of forest development in Serbia and by the Spatial Plan.

Of the total area of bare lands for afforestation, about 60% is private property, and about 40% is state property.

The organised realisation of the ambitious long-term plan of afforestation requires the following preconditions:

- Without delay, form the cadastre of eroded bare lands for afforestation. They should not be categorised as agricultural lands and they should be verified in the cadastre as the new cadastral category "bare lands for afforestation" with relevant data which diagnose the characteristics of these lands and their systematisation.
- These lands should be spatially defined, mapped and recorded in the Cadastre in the same way as the other land use types: municipality, cadastral community, numbers of cadastral parcels, and property. Of course, this should be regulated by a special Law, which should clearly define the methods of field research, the structure of parameters which diagnose the characteristics of the degraded bare lands, the profile of the professionals for the field work, the cameral processing data, and the same cadastral files and records as for other land types.
- The Law should define the source and the scope of financial resources for the realisation of this program. If a good-quality program is elaborated, we can expect the possibility of foreign investments, because the international community is very much interested and it has the available financial resources for the "ecological enhancement" of our planet.

When the cadastre of eroded bare lands is formed (these lands can also be named: "lands damaged by degradation and unproductive for agriculture"), the projects of afforestation should be designed, with the exact data on the property and geographic location of the parcels, ecological diagnose of the area for afforestation, optimal afforestation methods and technologies, and the optimal organisation of afforestation, with the real forecast of the development of these anthropogenic forest ecosystems.

It can be applied for the foreign subventions or credits for the realisation of the above projects, especially when Serbia becomes a member of the European Union.

One of the basic preconditions of the successful organisation of the realisation of the long-term afforestation projects is the supply of balanced continuous extra-budgetary financial means for the investments in infrastructural works in forestry.

It is our opinion that this matter should be regulated by a special law which should define the forms of infrastructural works in forestry, which should be financed by irretrievable means, where the afforestation of bare lands is the dominant commitment, with equal treatment of both the state and the private property. The integral right to land property should not be assumed, and the owner will be committed to tend the established forest plantation and to implement the protection measures, using the irretrievable means.

A very favourable experience was the method of getting the extra-budgetary financial means for infrastructural investments, the method of organisational management of these means for infrastructural investments, the method of organisational management of these means by the establishment of independent self-management communities for infrastructural investments in forestry of the Republic and the regional communities united into one system which operated based on their enactments, and under the social supervision by the Managing Boards and assemblies of the delegated citizens.

It is possible in the present social-economic and political conditions to establish an organisation which would dispose of the extra-budgetary means and their engagement in the realisation of the projects of infrastructural works on the afforestation and enhancement of the degraded forest ecosystems.

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BIOLOGICAL REHABILITATION BY AFFORESTATION AS THE POSSIBILITY OF LAND USE ENHANCEMENT

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Abstract: *Rehabilitation of degraded lands is a complex process consisting of mining engineering, reclamation, agroengineering, forestry and other works, in the aim of establishing the productivity of the disturbed lands and restoring the suitability for different forms of rational utilisation.*

The greatest percentage of degraded lands is created by the extraction of mineral resources by opencast mining. The use of heavy machinery in the removal of overburden and its deposition causes the disturbance of huge areas of productive agricultural or forest lands, and not rarely the translocation of the entire settlements and infrastructural features. The other major cause of land degradation is the refuse from the processing industry, where waste dumps are formed in the direct vicinity by the mechanical piling or tailings of waste material, cinder and slag.

The devastating consequences of the above processes can be solved by land rehabilitation. One of the most successful forms of rehabilitation is biological recultivation by afforestation. It is a complex procedure of creating a system which integrates several significant and interrelated processes. The research in this field is focused on the methods which should accelerate all the processes of generating the ferile soil, establishment and restoration of ecosystems, as the base of planning the development of the rehabilitated space.

This paper presents, on the example of the opencast mine in the Kolubara region, the predicted method of the rehabilitated land use, as well as the changes of land use, taking into account the changes resulting from the anhtropogenic impact, but also by the concentration of a great number of people at the industrial plants for the extraction and processing of raw materials.

Key words: biological rehabilitation, afforestation, degraded lands

1. INTRODUCTION

Rehabilitation is applied to damaged soils or deposited substrates which mostly result from:

1. Exploitation of mineral resources (coal, copper, marl, bauxite, non-metals, stone, gravel, etc.)
   a) by opencast mining technology
   b) by deep mining.
2. The substrates formed by processing industry
   a) ash storage pits near thermoelectric power plants
   b) slug pits near metallurgical combines

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c) waste tips near aluminium combines

d) contaminated soil by copper mine tailings.

3. Urban waste tips.

The largest areas of damaged land result from the extraction of mineral resources by opencast mining. The use of machinery for overburden removal and its deposition causes the disturbance of huge areas of productive agricultural or forest lands. It is often necessary to translocate the entire settlements, infrastructure, industrial plants, etc. A series of environmental elements may be changed (vegetation, plant and animal life, regimes of subterranean and surface waters,...). In Serbia, the size of lands damaged by opencast mining is considerable:

- coal opencast mines - nine locations,
- copper mines - four locations,
- ferronickel - two locations,
- one of the two lead and zinc mines is an opencast mine,
- and others.

Ore extraction by deep mining causes less damage to fertile soil, because the quantity of rock waste from the subsurface workings, dumped on the surface is small, but even as such, it disturbs the terrain configuration and destroys the vegetation in the area where it is dumped and, by its characteristics, it is also deposol.

The waste from the processing industry is physically and chemically modified. It is formed by the processing of raw materials, or during the combustion of solid fuels with high ash content. For this reason, the rehabilitation of the waste is difficult and long-lasting. The spoil heaps are formed by mechanical deposition of tailings.

2. REHABILITATION

With the increase of plans for ore extraction by opencast mining, the consequences with adverse effects to the environment also increase. The prediction of the future destructive consequences lead to the more intense awareness of the need of solving the issues related to the destruction of fertile soil and the reinstatement of life by the rehabilitation of the devastated spaces.

The first attempts on rehabilitation were recorded in Germany and USA by the middle of the 19th century, in England at the beginning, and in Serbia in the second half of the 20th century. The greatest success in the field of rehabilitation by afforestation was achieved in Germany, where several tens of thousands of hectares were reinstated, while in Serbia to date, rehabilitation has been performed on about 1,000 ha.

The rehabilitation procedure consists of two main phases: <u>Technical rehabilitation</u> which includes selective deposition of overburden, ranging between 100-150 m, and in some cases even more. The essence of selective deposition is that the upper, humus layer is temporarily stored, and the other layers of the overburden are uniformly deposited on the surface, taking care that the shaping of the deposited material is in harmony with the configuration of the surrounding terrain. Also, special attention is focused on the slopes of the external stock piles if they are above the elevation of the surrounding land, to ensure the drainage and infrastructure. In the end, the humus layer, which had previously been temporarily stored, is overlaid. The stock pile prepared in this way makes the phase of <u>biological rehabilitation</u> much easier. In our conditions, for the time being, selective removal of overburden is not practised because of the high costs, so biological rehabilitation is more difficult and it lasts longer. The spoil heaps from deep mines are high, with steep slopes, subject to erosion, so technical rehabilitation consists of decreasing the slope by terracing.

Based on the study results, three categories of biological rehabilitation are defined:

1. self-rehabilitation – spontaneous rehabilitation without human intervention, by spontaneous invasion of autochthonous vegetation. This process is also called revitalisation;
2. rehabilitation – rehabilitation by afforestation, or by fruit orchard establishment;
3. eu-rehabilitation – complete rehabilitation when all agro-technical measures are applied – agricultural rehabilitation.

3. WHY BIOLOGICAL REHABILITATION BY AFFORESTATION?

The extraction of mineral ores by opencast mining deteriorates huge areas of fertile soil and creates the surfaces made of crushed inert material of different geological composition. It is known that fertile soil is naturally created by the interaction of the inert substrate and the plants, which produce the energetic material that activates the biochemical processes and the generation of humus. Without biological activity, there is no fertile soil. Consequently, the essence of the generation of fertile soil is the introduction of organic matter into the sterile substrate of the deposited material, by the vegetation reinstated by biological rehabilitation of degraded spaces.

The rehabilitation by afforestation consists of two processes: rehabilitation by planting forest woody species and revitalisation by introducing autochthonous ground vegetation. This increases the input of organic matter and thus accelerates the revitalisation of the substrate. In this way, two basic aims are achieved in the reinstatement of the degraded land: 1. Revitalisation of the substrate and the initiation of soil processes and their biological circling is accelerated, and 2. during the process of photosynthesis, forests generate great quantities of oxygen, necessary to all spaces with air pollution. Only the above two benefits – creation of a great amount of organic matter which is returned to the soil and the release of a great quantity of oxygen, are sufficiently significant to render the rehabilitation by afforestation the absolute priority in planning the biological rehabilitation, wherever it can be offered as an alternative.

Rehabilitation by afforestation, as well as forest plantation establishment on eroded lands, is a complex procedure of creating the system which integrates several significant and interrelated processes. The selection of forest species, the quality of planting material and the method of plantation establishment should be based on the analysed climate and microclimate conditions and on the analysis of physico-chemical characteristics of the substrate to be rehabilitated. If all the above is done correctly, based on the previous experience, and by applying the scientific achievements, the established plantations will fulfil optimally their basic function of biological rehabilitation – production of the maximum quantity of biomass.

4. REHABILITATION IN THE AREA OF “RB KOLUBARA“

The lignite deposits interesting for exploitation in this Basin occupy the area of more than 500 km^2

Opencast mining started from the most eastward part of the deposit – fields "A" and "B", and continued in the field "D", "Tamnava-East field". The latest field is "Tamnava-West field".

The area of the Kolubara-Tamnava lignite basin has been subject to impressive works on the revitalisation and management of the degraded areas resulting from overburden deposition after lignite extraction.

The rehabilitated area consists of forests – 74.7%, nurseries 1.8% farmland 22.2%, orchards 1.3%, i.e. agricultural rehabilitation accounts for 23.5%. Such initial ratios of different ecosystems are justified if we consider the fact that forest ecosystems are of the highest significance for environmental protection and maintenance. A more significant percentage of agricultural ecosystems are planned with the further process of coal exploitation and biological rehabilitation.

The first afforestation of minespoil banks was performed in 1957 on the opencast mines of the fields "A" and "B", by planting predominantly black locusts. During the period 1957-1959 and in 1969, 110 hectares were afforested. A part of these plantations has been restituted to the private landowners as the compensation for the new expropriated areas, the land use of a part of the area has been changed, so today "Kolubara" holds 74.90 ha of black locust forests

The opening of the new mines ("Tamnava-East field" and field "D") will degrade further areas, so the reclamation of the degraded environment is becoming increasingly topical.

At the same time, it is evident that the issue of biological rehabilitation cannot be approached inattentively, so the study of environmental conditions and the formed deposols has been undertaken. The guidelines for further work are based on the research and the world-wide achievements, and the concrete spoilbank areas are afforested based on the project designs.

The first project of biological rehabilitation by afforestation is based on the previous ecological, phytocoenological and pedological researches of deposol, performed in 1977 (Institute of Forestry, Belgrade). Since that time, the biological rehabilitation by afforestation has been performed based on the previous projects, in cooperation with the Institute of Forestry.

The more intensive work on biological rehabilitation by afforestation started in 1973. Till the end of 1996, the afforested area amounted to 971 hectares.

Till 1997, the rehabilitated area was 1,306 hectares (Table 1.)

Table 1. Biological rehabilitation performed till 1997

Rehabilitation type	Exploitation fields			Total ha	
	"A"+"B"	"D"	"Tamnava-East"	ha	%
Forest rehabilitation - forests	301	610	60	971	74.7
Nurseries	-	15	5	20	1.8
Agricultural rehabilitation -farmlands	40	235	23	298	22.2
Orchards	6	11	-	17	1.3
Altogether agricultural rehabilitation	46	246	23	327	23.5
Total biological rehabilitation	347	871	88	1,306	100

Several species of coniferous and deciduous trees were used for afforestation, depending on micro-ecological conditions and deposol type (Table 2.). The largest area is covered by pure plantations of Austrian pine and Scots pine (27.2%), and by group-selection mixed plantations of conifers and broadleaves (23.2%). The group-selection mixed plantations of conifers account for 11.1% of the total afforested area, and mixed plantations of broadleaves 9.6%.

The percentage of other broadleaves - lime, alder, Siberian elm, birch and others is 7.9%, and black locust 8.4% of the total afforested area, while the percentage of other listed species is from 1.3% to 3.4% of the total plantation area.

A relatively high number of species is applied in the afforestation of stock piles not only because of the high variability of the micro-ecological conditions over a small area conditioned by the non-selective deposition of waste, but also due to the tendency to enrich the landscape of the created forest ecosystems whose valorisation should be directed towards the post-exploitation land use as a leisure and recreation zone, as it is situated in the direct vicinity of Belgrade and other smaller industrial towns, whose population should be offered some psycho-physical relaxation in the open air.

Table 2. Forest plantation areas per tree species and age

Tree species	Total		Age classes (years)		
	ha	%	< 5	6-10	>10
Pure plantations of Austrian pine and Scots pine	262.00	27.7	88.00	34.00	140.00
Pure plantations of larch	33.00	3.4	10.00	6.00	17.00
Pure plantations of Douglas-fir	13.00	1.3	-	-	13.00
Pure plantations of Weymouth pine	21.00	2.1	-	-	21.00
Pure plantations of oak	23.00	2.3	-	13.00	10.00
Pure plantations of maple	29.00	3.0	2.00	13.00	14.00
Pure plantations of black locust	82.00	8.4	7.00	-	75.00
Pure plantations of other broadleaves	78.00	7.9	48.00	20.00	10.00
Mixed plantations of conifers	109.00	11.1	-	12.00	97.00
Mixed plantations of broadleaves	93.00	9.6	15.00	40.00	38.00
Mixed plantations of conifers and broadleaves	228.00	23.2	-	63.00	165.00
Total	971.00	100.0	170.00	201.00	600.00
% per age classes	100.0	-	18.3	20.5	61.2

All the tree species applied in the afforestation have a high degree of survival after planting and a very good dynamics of diameter, height, and volume development in general. However, there is a difference between the species on the analogous (identical) deposols, as well as the difference in the development of each species on different deposols.

Monitoring of the development of planted trees and shrubs enables the optimal selection of species for afforestation for each type of deposol, which will show the best development and productive effects, vitality, ornamentalness and other functional values.

The existing forest plantations have a good stocking and canopy closure, but in the last ten years or so, they have not been thinned, or tended by cleaning dead branches, which can have an adverse effect on their further development, stability and productivity. Therefore, all plantations above 12 years of age should be thinned aiming at the maintenance of the optimal canopy closure and stocking.

To apply the optimal silvicultural measures, which also depend on the permanent land use, the long-term spatial, urbanistic or other plans should define the land use of the forest rehabilitated areas in the post-exploitation period. This should be taken into account in the design of spatial plans, i.e. in the development planning of the Kolubara-Tamnava basin in general, and in the reclamation and management of the areas on which natural ecosystems were destroyed by opencast mining of lignite.

Taking into account the great concentration of the population and the state of the environment, forest ecosystems established in the procedure of biological rehabilitation have an extraordinary significance in the zone of effect of opencast mines, especially in the area of the Municipality Lazarevac.

In the present phase of exploitation and rehabilitation of the Kolubara Basin, it is still not possible to define the future land use of the area and to propose a more appropriate approach to the rehabilitation. Coal exploitation is limited by space and time. On some areas, opencast mining has been completed, or is nearing the end, and the works on different forms of rehabilitation are underway. Forest plantations of broadleaves and conifers of different ages, as well as agricultural areas have already been established.

As it can be seen from the above, opencast coal mining requires the management of the entire area and the overburden masses above the coal. The rehabilitation and the restructuring of overburden masses offers greater options for the selection and structuring of the land to meet the needs and goals of human and natural communities, than in any other method. The selection of post-mining land use has to be based on the culturological factors of the surrounding communities, not neglecting the production-economic effects.

In the countries with the fixed regulations, the rehabilitation standards can be the most significant factors in the selection of the post-mining land use. The common method of regulatory control is that the local, provincial and national state agencies must be asked for the approval of any proposed plan of coal mining before starting the works (Australia, Canada, EEC, South Africa and USA). The common elements in many laws include the selective deposition, especially of the fertile humus layer and overburden, the reshaping of the land according to its original contours (USA and Great Britain legislation), the government supervision of the land rehabilitation, to be sure that sustainable vegetation has been established, and the payment of restoration bonds, or other form of financial guarantee, before commencing opencast mining developments.

The successful rehabilitation and space management needs the appropriate public relations. It is necessary to convince the people (planners, technocrats, scientists, local population) that the post-mining areas with a high degree of naturalness and biodiversity are a contribution to the well-being of the entire population. It is especially important to discuss openly the establishment of species which require a high "degree of landscape maturity", because they have high territorial demands, or are on the top of the food chain.

The post-mining areas are very important research spheres, they offer a unique opportunity of testing the ecological hypotheses on the primary succession which cannot be found anywhere in the European cultural landscapes. The regional plans and legislation should integrate and apply more than the current concept of conservation. This includes the sustainable concept of respecting the principles of ecology and economy after the rehabilitation of the mined landscapes has been completed, or even after the final cessation of coal exploitation.

Based on the research of coal mining in REIK Kolubara, each 10,000 t of coal destroys 1,000 ha of fertile soil. Despite the great difficulties caused by non-selective deposition of overburden and by the absence of previous technical rehabilitation and planned shaping of the spaces in some areas planned for forest-biological rehabilitation, in the area of Kolubara Basin excellent results of successful afforestation and the dynamics of development of different broadleaf and coniferous tree species have been achieved.

Extraordinary anthropogenic forest ecosystems have been created, rich in colours, polyfunctional values, enriched by aquatic and meadow-grass ecosystems, which make an excellent base for further spontaneous evolution of rich phyto- and zoo- biodiversity, multiply richer than that existing in the pre-mining period.

5. CONCLUSION

It is a fact that opencast mining of mineral resources in Serbia will proceed, so the consequences of environmental degradation will continue in the future period, destroying both the close-to-nature ecosystems and the anthropogenically created ecosystems.

The example of the Kolubara Basin shows that it is not necessary that what man has degraded or destroyed for his needs, be irrevocably lost. By the correct procedures from the moment of planning, through exploitation, till the final landscape management, the state can be improved compared to the original situation. This requires the cooperation of experts of different sciences and specialties (mining engineering, forestry, landscape architecture, biology, agronomy, etc.) and a multidisciplinary approach to the solving of this extremely complex issue.

The documents of mining developments should always be accompanied by the timely elaboration of the project analysis of the effects on the environment and by the projects of technical and biological rehabilitation with the reinstatement of the degraded lands.

The optimal solutions can be found by the research and project-plan documents aiming at the best multi-functional effects in the ecological-economic restoration of the lands degraded by opencast mines. Project documents should clearly define the ratio of agricultural, forest, aquatic and other areas, their distribution in space, the new and existing settlements, population structure, types of activities to be pursued, the accompanying infrastructure, etc.

By the procedure of technical (mining) rehabilitation, the new image of the space is physically created, with the mitigated contours and with the final fertile humus layer. However, it is only with the biological rehabilitation that the life returns to the damaged lands. By planting different tree and shrub species, the new plant communities are anthropogenically established and the complex coenological processes commence, followed by spontaneous invasion of both flora and fauna. Synergistically, they affect the soil, enrich the soil with organic matter, initiate the microbiological activity and soil formation processes. In time, the rehabilitated and revitalised area fits in the surrounding landscape and creates a harmonic and functional unit.

In addition to the melioration effect on the soil, other useful functions of the established forest ecosystems are also essential. One of the main functions is its retention-protective function. Forest plantations and the spontaneously invaded ground flora will prevent the development of sheet and rill erosion. By its green leaf mass, forests have a significant function of purifying the contaminated air, both by the decomposition of the chemical compounds, and by the deposition of particulates, which is very important from the standpoint of environmental protection in the zone of settlements.

It should be insisted that forest ecosystems, as the greatest sinks of carbon dioxide and other pollutants and the most efficient filtrants of the particulates in the ground air layers, are given the preference in the biological rehabilitation, especially at places where forest percentage is low and where there are no forest ecosystems between the mines and the larger urban settlements.

To upgrade the above developments, especially the selection of species, it is necessary to continue the analysis of the established plantation increment on deposols, especially the production of organic matter in the form of forest litter, the rate of its decomposition and humus generation, and the initiation of pedological processes. The selection of species should be based on the exact study data. Such research has already been started at the Institute of Forestry in Belgrade.

The results attained in the rehabilitation by afforestation of the Kolubara Basin confirm that, in the areas of destroyed ecosystems and natural landscapes, new forest, aquatic and meadow ecosystems can be created, with improved and attractive landscapes and with more functional values than the natural ecosystems of the pre-exploitation period. This verifies the thesis on the possible sustainable development, i.e. on the possible sustainable exploitation of minerals and other resources.

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IMPACT OF FOREST ECOSYSTEMS UPON SOIL EROSION AND RUNNOF REGIME IN THE DRAINAGE BASINS IN MOUNTAINOUS REGIONS

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Abstract: *Soil erosion is a very complex process. The process starts at the moment when a rain drop hits soil surface causing soil destruction. Detached and washed particles reach the hydrographic network of the stream and constitute its solid phase sediment. The development of erosion in a drainage basin depends on the sum of its basic interacting natural phenomena, such as: climate, relief, parent rock, soil type, state of vegetative cover, etc. It is considered that permanent vegetation, first of all forest, is the strongest factor which opposes the adverse effects of erosion.*

The runoff from a drainage basin is conditioned by a multitude of different factors entering a complex and unrepeatable combination for any site under consideration. Surface runoff, or overload flow, is formed when the soil is no longer capable of absorbing rainwater, nor it can be consumed in the processes of transpiration, infiltration and sub-surface runoff. The runoff regime depends on the simultaneous action of many factors which can be classified into the two groups:

1. Abiotic factors: relief and geomorphological characteristics, parent rock and soil composition, climate (first of all the intensity and amount of rainfall),

2. Biotic factors: vegetative cover of the slope, land use anthropogenic factors, etc. This group of factors is more interesting because they maintain the stabilizing effect of the forest cover as well as the economic activities.

The vegetational cover, and first of all the forest one, represents one of most powerful factors influencing the runoff regime, since by its effect it modifies and moderates the others.

This paper presents the results of research of impact of forest ecosystems on soil erosion and runoff regime in the drainage basins in mountainous regions. The research were carried out in the experimental drainage basins and on runoff plots.

Key words: forests, vegetative cover, soil erosion, runoff regime, sediment transport

1. INTRODUCTION

The runoff from a drainage basin is conditioned by a multitude of different factors entering a complex and unrepeatable combination for any site under consideration. Surface runoff, or overload flow, is formed when the soil is no longer capable of absorbing rainwater, nor it can be consumed in the processes of transpiration, infiltration and sub-surface runoff. Overland flow depends on the simultaneous action of many factors which can be classified into the two groups:

1. Abiotic factors: relief and geomorphological characteristics, parent rock and soil composition, climate (first of all the intensity and amount of rainfall),

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2. Biotic factors: vegetative cover of the slope, land use anthropogenic factors, etc. This group of factors is more interesting because they maintain the stabilizing effect of the forest cover as well as the economic activities (*Nedyalkov, S., Raev, I., 1980*).

The vegetational cover, and first of all the forest one, represents one of most powerful factors influencing the runoff regime, since by its effect it modifies and moderates the others. Annual value of specific discharge is a very important indicator of the runoff regime in a drainage basin, necessary in research and projects aiming at reclamation, water supply, power supply, etc. Also, maximum discharge and maximum specific discharge are significant indicators of the runoff regime in a drainage basin.

Soil erosion is a very complex process.The process starts at the moment when a rain drop hits soil surface causing soil destruction. Detached and washed particles reach the hydrographic network of the stream and constitute its solid phase sediment. The development of erosion in a drainage basin depends on the sum of its basic interacting natural phenomena, such as: climate, relief, parent rock, soil type, state of vegetative cover, etc. It is considered that permanent vegetation, first of all forest, is the strongest factor which opposes the adverse effects of erosion. Forests reduce soil erosion in the drainage basin , and reduce the yield of sediment from drainage basin.

Soil erosion (water and wind erosion) causes great damages, such as: soil loss, water loss, loss of nutrients, dusturbance of runoff regime in the drainage basins, catastrophic floods, reservoirs siltation etc.. Damages initially caused by erosion is the loss of the upper fertile soil horizon, coupled with loss of organic and mineral nutrients from steep and ploughed land, leading to inadequate air and water relations in the soil. The damage caused by water erosion results from detaching and transporting the fertile soil horizon from the slopes, as well as from torrential flows. Erosion removes organic and mineral nutrients from the top soil, the soil structure is destroyed leading to the disturbance of soil characteristics of air and water relationship.

Water erosion and sediment transport, along with its general consequences (soil loss, water loss, disturbance of runoff regime, torrential floods, reservoir siltation, irrigation and drainage systems siltation, etc.) causes great damages which can be classified as ecological effects. In the process of runoff on eroded slopes, along with soil particles (erosion sediment), all the other substances contained in the eroded soil layer are also removed. After reaching the streams and reservoirs, erosion sediment has the following ecological (and other) adverse effects: a)environmental degradation of the landscape due to the soil loss, b) mechanical pollution of stream and reservoir water by the sediments, c) chemical pollution of water by manures, fertilizers and pesticides.

Soil erodibility factor (K), used in USLE (Universal Soil Loss Equation), denotes the soil susceptibility to erosion processes. This characteristic of soil material unites the following properties: texture, permability, structure, contents of total humus and organic matter. Most of these properties depend on plant cover. Plant cover, first of all forest vegetation as an essential source of organic matter, determines the chemical nature of organic matter input on end in the soil biologica activity of the soil, the character of humus and the balance of nutrient circulation in the ecosystem. The character of the prodused humus, i.e. its group-fractional composition, affects the relations of organic matter and mineral component and therefore the role of humus as a cementing material in the creation of soil structure. The size and stability of structural aggregates determine the relationship of various categories of soil pores, and consequently also soil permability.

When an autochthonous forests is replaced by another tree species, the character and chemical nature of the organic matter which forms humus is completely changed. The degree of changes occurring in the soil depends on the introduced tree species, site characteristic and the lenght of the period of influence.

Figure 1. Sheet and Gully Erosion in the Slope of Drainage Basin

This paper presents the results of research into the runoff regime, soil erosion and sediment transport in three experimental drainage basins in West Serbia. These drainage basins are characterized by similar natural features, the only difference being the degrre of forest cover. In the Lonjinski Potok drainage basin, 70,35 % of the area is under well-stocked forest, whereas the percentage in the Dubošnički Potok is 48,52%, and in the Đurinivac Potok drainage basin it is 39,50%.

2. SUBJECT AND METHOD OF RESEREARCH

2.1. Study Area

The researchs were caried out in three small experimental drainage basins in West Serbia: Dubošnički Potok, Lonjinski Potok and Đurinovac Potok. The drainage basins of the streams are typical small torrential drainage basins. All the three experimental drainage basins are the right tributaries of the river Drina and they are torrential streams. The drainage basins are situated on the territory of the community Ljubovija in West Serbia (Fig.2). They are in a hilly mountainous region, which can be seen from their main topographic features given in Table 1 (*Kostadinov S., 1996*).

Parent rock is the same in all the three drainage basins, i.e. a sandy-schistose series consisting of metamorphosed sandstones, phylites, agrilloschists and more rarely sericites, green schists, quartz breccias, quartzites and marbles.

The soil in the three drainage basins is acid brown soil on schists (skeletoid).

The vegetative cover, i.e. land use, is different in the three experimental drainage basins. Table 2 is a survey of land use. As it can be seen, in the Lonjinski Potok drainage basin 70.35% area is under well-stockted forests, in the Dubošnički Potok drainage basin 48.52%, and in the Đurinovac Potok drainage basin 39.5%. The vegetative cover in all the three drainage basins has the same characteristics. Significant areas are covered by very degraded forests transformed into very thin brushwood of eastern hornbeam, ash and oak, where very strong rill erosion occurs.

Figure 2. Study Area

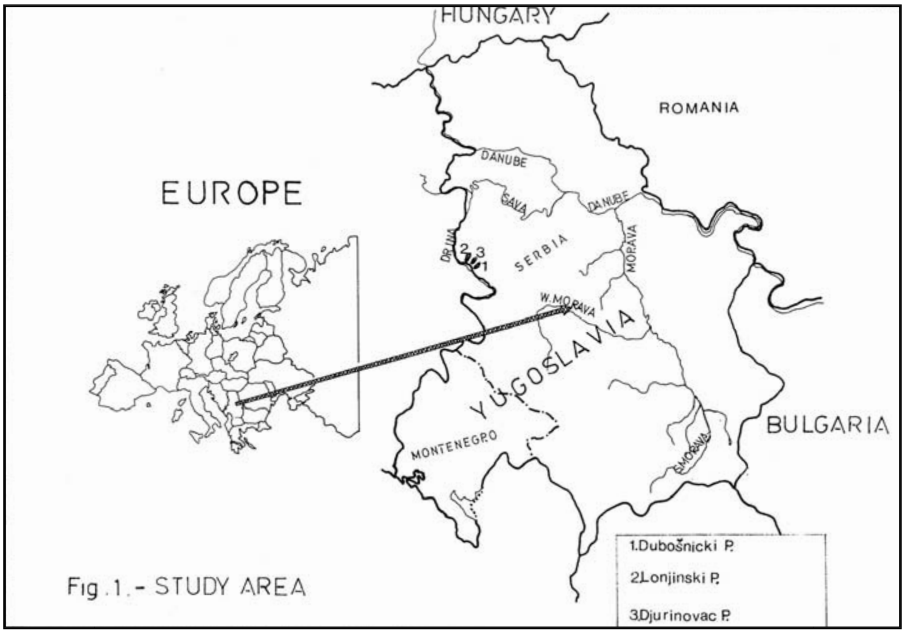


Table 1. Parameters of the Drainage Basins

PARAMETERS	SYMBOL	DUBOŠNIČKI POTOK	LONJINSKI POTOK	ĐURINOVAC POTOK
Drainage basin area	F - km^2	1.2464	0.7656	0.544
Drainage basin perimetre	O - km	5.25	3.60	3.55
Drainage basin length	L_{gl} - km	2.48	1.40	1.40
Drainage density	G – $km{\cdot}km^{-2}$	3.26	2.38	4.04
Mean elevation of the drainage basin area	N_{sr} - m	487.90	363.90	299.70
Mean slope of the drainage basin area	I_{sr} - %	47.24	38.87	43.59
Stream-bed slope	I_t - %	18.37	18.94	12.63
Erosion coefficient	Z	0.56	0.34	0.49

The vegetative cover in all the three drainage basins has the same characteristics, which is normal, because the drainage basins are near each other.

Significant areas are covered by very degraded forests transformed into very thin brushwood of eastern hornbeam, ash and oak, where very strong rill erosion occurs.

The following associations are well-stocked forests:

- Forest of Hungarian oak and bitter oak - *Quercetum farnetto cerris* Rud., with the sub-association *Carpinetum orientalis serbicum*.
- Forest of beech in the mountainous belt - *Fagetum submontanum*. In addition, there are some artificially established plantations of black locust (*Robinia pseudoacacia*), Austrian pine

Table 2. Land use in the Drainage Basins (Vegetative Cover)

CULTURE	DUBOŠNIČKI POTOK		LONJINSKI POTOK		ĐURINOVAC POTOK	
	km2	%	km2	%	km2	%
Pasture	0.0224	1.80	0.014	1.83	-	-
Meadov	0.1768	14.18	0.07	9.14	0.0764	14.04
Plowland	0.0256	2.05	0.03	3.92	0.0136	2.50
Farm yard	0.0304	2.44	0.012	1.57	0.057	10.48
Orchard	0.0784	6.29	0.023	3.00	0.0168	3.10
Degraded forest	0.2848	22.86	0.078	10.19	0.1456	26.76
Well stocked forests	0.6048	48.52	0.5386	70.35	0.2149	39.50
Bare land	0.0232	1.86	-	-	0.0197	3.62
Total	1.2464	100	0.7656	100	0.544	100

(*Pinus nigra*) and Scots pine (*Pinus sylvestris*). They are still young plantations, but they are a sufficient protection from erosion (*Kostadinov 1985*).

Table 3. Distribution of Erosion Processes in the Drainage Basins

CATEGORY	Z	DUBOŠNIČKI POTOK		LONJINSKI POTOK		ĐURINOVAC POTOK	
		km^2	%	km^2	%	km^2	%
I excessive erosion	1.25	0.0862	6.92	0	0	0.048	8.80
II intensive erosion	0.85	0.2296	18.42	0.0428	5.60	0.025	4.60
III medium erosion	0.55	0.504	40.44	0.1922	25.10	0.204	37.50
IV weak erosion	0.30	0.3698	29.66	0.3202	41.82	0.219	40.30
V very weak erosion	0.10	0.0568	4.56	0.2104	27.48	0.048	8.80
total		1.2464	100	0.7656	100	0.544	100
mean coeff. of erosion		**Z = 0.56**		**Z = 0.34**		**Z = 0.49**	

As the result of different degrees of forest cover, erosion processes of different intensities develop in the drainage basins. The most intensive processes of erosion occur in the Dubošnički Potok (Z - 0.56, medium erosion) then in the Đurinovac Potok (Z - 0.49, medium erosion), whereas the weakest processes of erosion occur in the Lonjinski Potok (Z - 0.34, weak erosion), Z - denotes the coeficient of erosion in a drainage basin or in erosive area, according to *S. Gavrilović* (*Gavrilović, 1972).*

2.2.Study Methods

According to the aims of the research, in the selected experimental drainage basins, discharge measurements as well as suspended sediment and bedload transports, were recorded by means of regulated hydrometric profiles. Precipitation data were also recorded.Water discharge was measured by a measuring rod and by a limnigraph. Suspended sediment transport was measured by taking samples of water and by determining the concentration of solids. The concentration was determined by filtration method. Water sampling was carried out every day, and during the periods of flood wave, it was repeated several times during the wave. Bedload transport was measured by volume method. The sediment was retained in an accumulation space of check dams. Bedload transport was measured after every flood wave by means of the precise level method.Based on the measurements at the cross sections, the balance was made of water disharge and suspended sediment, bedload and total sediment load for individual flood waves, for days, months and for the whole year.

To asses the changes of dystrict cambisol erodibility, after the substitution of beech coppice forests with spruce and fir plantations, two sample plots were established at Tornička Bobija in northwest Serbia. For each sample plot, the soil was analysed under natural beech stand and under 30-year-old plantation of fir and spruce. Laboratory analyses included:

- Reaction of soil solution electrometrically,
- Sum of exchangeble and soluble basic cations, after Bover at Atens (1952),
- Total humus and organic matter by Tiurin`s method, and humus group-fractional composition by Ponomeriev`s method modified by Simakov,
- Soil texture, by sedimentation with Na-pirophosphate as peptizing agent,
- Stability of microstructural aggregates, after Wageler,
- Erodibility factor vas calculated by the equation after R. Lal.

2.1. Stages of research

The complete research includes the following stages:

- collection and study of the existing documentation on the experimntal drainage basins: Project of erosion control works (ECW), documentation of implemented ECW
- the study of natural characteristics and the analysis of physical-geographical factors of sediment formation (state of soil erosion processes in the drainage basins)
- measurement of water disharge
- measurement of sediment transport (suspended and bedload)
- analysis of the effect of spruce and fir plantations astablished on beech site on district cambisol erodibility

Natural characteristics of the drainage basins were studied based on reference data (climate, geology, soil) and the direct reconnaissance (vegetation and erosion processes). The analysis of phisical-geographical factors of sediment formation was carried out after Gavrilović (1972). Rainfall was measured by rain gauge. Disharge and sediment transport (suspended and bedload) were measured on equipped cross sections according to the method adapted for torrential flows *(Kostadinov, S. 1985).*

3. RESULTS OF RESEARCH

3.1. Precipitation and Runoff

Table 4 presents the annual values of rainfall and runoff. The symbols in the table denote:

H_{year} - annual precipitation depth in *mm*,

M_Q - annual specific discharge in $L \cdot s^{-1} \cdot km^{-2}$,

Q_{max} - maximum discharge observed in a year in $m^3 \cdot s^{-1}$,

Q_{sp} - maximum specific discharge observed in a year in $m^3 \cdot s^{-1} \cdot km^{-2}$,

n - number of days in a year, when the stream went dry.

The highest average annual recipitation value was observed in the Lonjinski Potok drainage basin (804.6 *mm*), and the lowest in the Dubošnički Potok (764.7 *mm*). Also in the Lonjinski Potok drainage basin the highest annual specific discharge was recorded (7.97 $L \cdot s^{-1} \cdot km^{-2}$), whereas in the Dubošnički Potok the smallest annual specific discharge (6.25 $L \cdot s^{-1} \cdot km^{-2}$) was observed.

The highest average annual maximum discharge were recorded in Dubošnički Potok (0.406 $m^3 \cdot s^{-1}$), and the lowest in Lonjinski Potok (0.110 $m^3 \cdot s^{-1}$). This is drastically expressed in the case of maximum specific discharge observed in a year - Q_{sp}. The highest average annual values were recorded in the Đurinovac Potok drainage basin (0.731 $m^3 \cdot s^{-1} \cdot km^{-2}$), and the lowest in Lonjinski Potok (0.143 $m^3 \cdot s^{-1} \cdot km^{-2}$).

Table 4. Annual Characteristics of Runoff

Name of Drainage basin	Year	H_{year} *mm*	M_Q $L \cdot s^{-1} \cdot km^{-2}$	Q_{max} $m^3 \cdot s^{-1}$	Q_{sp} $m^3 \cdot s^{-1} \cdot km^{-2}$	n
Dubošnički Potok	1980	1020.3	13.74	0.456	0.366	24
	1981	984.5	10.45	0.376	0.307	98
	1982	794.8	5.90	0.174	0.140	7
	1983	687.3	1.75	0.174	0.140	137
	1984	705.5	12.80	0.456	0.366	49
	1985	509.5	4.14	0.174	0.140	104
	1986	722.6	4.47	0.965	0.774	191
	1987	873.0	4.99	1.050	0.842	205
	1988	602.1	2.15	0.028	0.022	185
	1989	747.1	2.12	0.203	0.163	214
	Average	764.7	6.25	0.406	0.326	121.4
Lonjinski Potok	1980	1054.7	12.44	0.073	0.095	0
	1981	911.2	10.16	0.073	0.095	0
	1982	829.6	7.78	0.055	0.072	0
	1983	768.0	5.64	0.073	0.095	5
	1984	946.1	14.58	0.360	0.470	0
	1985	651.3	8.63	0.073	0.095	5
	1986	612.2	3.76	0.040	0.052	0
	1987	995.5	11.73	0.428	0.559	0
	1988	737.1	8.26	0.073	0.095	0
	1989	875.2	9.83	0.334	0.435	5
	1990	700.0	3.52	0.028	0.036	41
	1991	828.4	6.34	0.040	0.052	5
	1992	1020.0	7.74	0.018	0.024	41
	1993	509.0	7.70	0.040	0.052	13
	1994	463.0	2.13	0.011	0.014	99
	1995	972.0	7.26	0.040	0.052	0
	Average	804.6	7.97	0.110	0.143	13.4
Đurinovac Potok	1981	1011.2	12.19	0.124	0.228	91
	1982	779.6	9.14	0.980	1.801	185
	1983	734.1	5.84	0.153	0.281	232
	1984	906.1	10.42	0.720	1.323	206
	1985	591.3	4.51	0.074	0.136	197
	1986	703.0	5.03	0.450	0.827	228
	1987	674.6	4.83	0.900	1.654	220
	1988	889.1	14.82	0.227	0.417	208
	1989	916.6	14.04	0.300	0.551	174
	1993	570.4	2.62	0.052	0.096	230
	1994	630.6	0.80	0.124	0.228	257
	1995	929.4	8.11	0.670	1.232	175
	Average	778.0	7.70	0.398	0.731	200.2

Lonjinski Potok dried up rarely (on a few occasions - average annual 13.4 days), whereas Dubošnički Potok, and Đurinovac Potok were very often without water. This was particularly true for the Đurinovac Potok drainage basin, for which it can be said that during the greater part of the year there was no stream flow (average annual number days without water was in Dubošnički Potok 121.4 and in Đurinovac Potok 200.2). The highest average annual recipitation value was observed in the Lonjinski Potok drainage basin (804.6 *mm*), and the lowest in the Dubošnički Potok (764.7 *mm*). Also in the Lonjinski Potok drainage basin the highest annual specific discharge was recorded (7.97 $L \cdot s^{-1} \cdot km^{-2}$), whereas in the Dubošnički Potok the smallest annual specific discharge (6.25 $L \cdot s^{-1} \cdot km^{-2}$) was observed.

The highest average annual maximum discharge were recorded in Dubošnički Potok (0.406 $m^3 \cdot s^{-1}$), and the lowest in Lonjinski Potok (0.110 $m^3 \cdot s^{-1}$). This is drastically expressed in the case of maximum specific discharge observed in a year - Q_{sp}. The highest average annual values were recorded in the Đurinovac Potok drainage basin (0.731 $m^3 \cdot s^{-1} \cdot km^{-2}$), and the lowest in Lonjinski Potok (0.143 $m^3 \cdot s^{-1} \cdot km^{-2}$).

Lonjinski Potok dried up rarely (on a few occasions - average annual 13.4 days), whereas Dubošnički Potok, and Đurinovac Potok were very often without water. This was particularly true for the Đurinovac Potok drainage basin, for which it can be said that during the greater part of the year there was no str eam flow (average annual number days without water was in Dubošnički Potok 121.4 and in Đurinovac Potok 200.2).

The most intensive processes of erosion have been observed in the Dubošnički Potok drainage basin and the weakest in the Lonjinski Potok drainage basin. The greatest amounts of average annual rainfall was recorded for the Lonjinski Potok, and the lowest amounts in the case of the Dubočnički Potok. The greatest transport of suspended and total sediment was recorded in the Dubošnički Potok, and the smallest in the Lonjinski Potok. It should be noted that in the Lonjinski Potok the transport of bedload as not recorded at all, it was only the suspended sediment. The specific mean annual transport of total sediment in the Lonjinski Potok was 4.50 times lower than in the Dubošnički Potok and 3.50 times lower than in the Đurinovac Potok.

Table 5 shows the precipitation and sediment transport (suspended and bedload) measurements per years, in four experimental drainage basins. The symbols in the Table 3 denote:

h_{max} - average value of maximal daily precipitation in a year, in *mm*,
H_{year} - average value oa annual precipitation, in *mm*,
M_R - annual specific transport of suspended sediment, in $m^3 \cdot km^{-2} \cdot year^{-1}$
M_V - annual speific transport of bedload, in $m^3 \cdot km^{-2} \cdot year^{-1}$;
M_G - annual specific transport of total sediment in $m^3 \cdot km^{-2} \cdot year^{-1}$.

According to R.Lal`s equation, soil erodibility factor points to significant differences between the soil under natural beech forests and the soil under spruce and fir plantations. These differences result primarily from the lower content of total humus in the first 10 cm of soil depth. Namely on both sample plots, neither experimental nor control soil samples showeds any greater differences in structure and infiltration, at least not sufficiently to modify the value of the code which enters the equation.

3.2. Discussion of the Results

The results of the research show that runoff regime in the Lonjinski Potok was balanced, without high peaks. Runoff in the Dubošnički Potok and Đurinovac Potok was discontinuous with large intervals of drought and the discharge was mainly in the form of flood waves. Unbalanced regimes of runoff in the Dubošnički Potok and Đurinovac Potok drainage basin were manifested, first of all in the fact that during a large part of the year they are dry. This is also confirmed by the data of maximum annual discharge (Q_{max} and Q_{sp}). Average annual height of maximum specific discharge in Lonjinski Potok was 5.1 timeslower than that in the Đurinovac Potok and 2.28 times lower than in the Dubošnički Potok drainage basin.

Table 5. Annual characteristics of precipitation and sediment transport

NAME OF DRAINAGE BASIN	YEAR	PRECIPITATION		SEDIMENT TRANSPORT		
		H_{year}	h_{max}	M_R	M_V	$\mathbf{M_G}$
		mm		$m^3 \cdot km^{-2}$		
DUBOŠNIČKI POTOK	1980	1020.3	47.5	57.91	225.10	283.01
	1981	984.5	42.3	81.55	30.91	112.46
	1982	794.8	31.5	76.46	34.86	111.32
	1983	687.3	28.2	28.26	14.69	42.95
	1984	705.5	45.0	254.22	52.45	306.67
	1985	509.5	42.2	44.33	256.65	300.98
	1986	722.6	32.0	32.67	33.76	66.43
	1987	873.0	47.0	316.01	464.55	780.56
	1988	602.1	36.0	3.31	0.00	3.31
	1989	747.1	28.0	106.98	57.99	164.97
average value		764.67	38.0	100.17	117.10	217.27
LONJINSKI POTOK	1980	1054.7	41.5	16.03	0.00	16.03
	1981	1011.2	45.2	38.01	0.00	38.01
	1982	779.6	41.5	48.16	0.00	48.16
	1983	768.0	49.4	40.26	0.00	40.26
	1984	906.1	46.2	64.31	0.00	64.31
	1985	591.3	26.0	13.46	0.00	13.46
	1986	612.2	27.1	3.01	0.00	3.01
	1987	995.5	76.9	119.84	0.00	119.84
	1988	737.1	54.1	90.98	0.00	90.98
	1989	875.2	38.0	32.63	0.00	32.63
	1990	700.0	35.5	12.97	0.00	12.974
	1991	1159.0	64.1	101.49	0.00	101.49
average value		849.16	45.5	48.43	0.00	48.43
DJURINOVAC POTOK	1981	1011.2	45.2	44.27	110.98	155.25
	1982	779.6	41.5	101.47	76.82	178.29
	1983	734.1	48.3	10.78	0.00	10.78
	1984	906.1	46.8	24.64	18.83	43.47
	1985	591.3	26.0	11.87	22.31	34.18
	1986	703.0	31.6	30.85	63.53	94.38
	1987	674.6	52.7	129.44	263.26	392.70
	1988	889.1	60.4	152.38	295.46	447.84
	1989	916.6	40.8	72.75	123.34	196.09
average value		800.62	43.7	64.27	108.28	172.55

Table 6. Soil Eerodibility Coefficient

Tree species	Texture				Total humus	Infiltration code	Texture code	Erodibility coefficient (K)
	Coarse send	Fine send	Silt	Clay				
	%	%	%	%	%			
Spruce	26.38	26.20	27.02	20.40	3.51	3	4	0.30
Beech	12.94	27.58	40.56	18.72	5.29	3	4	0.32
Fir	16.14	28.66	33.82	21.38	6.82	3	4	0.23
Beech	25.02	35.18	21.78	20.02	11.73	3	4	0.06

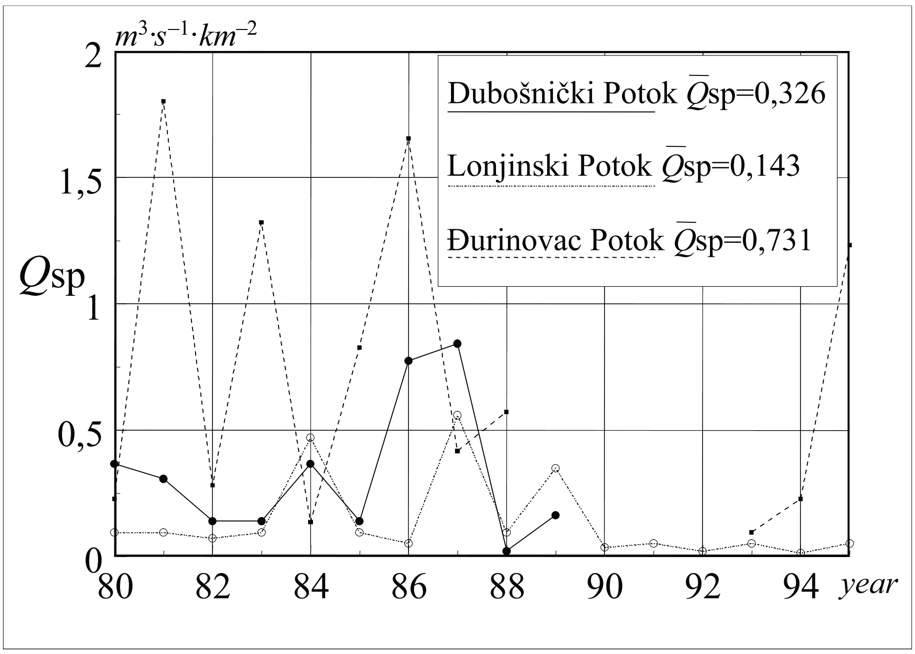
Bearing in mind that climate, parent rock, and soil are the same in all the three drainage basins, some other characteristics of the drainage basins had to be analyzed. The highest amounts of average annual precipitation were recorded in the Lonjinski Potok. Annual distribution of rainfall in the drainage basins was the same. Maximum monthly amounts were measured in May and in October.

According to topographic characteristics the Dubošnički Potok and Đurinovac Potok have a higher mean slope of drainage basin, but, on the other hand, the Lonjinski Potok has the highest stream-bed slope which means the highest transport capacity of the flow. Therefore, as for the slope, it can be said that it is similar in all the three drainage basins.

Consequently, the vegetative covering, i.e. the forest in this case, was the modifier of erosion and runoff regimes. The Lonjinski Potok has the highest percentage of area under well-stocked forests.

The results show that forests have an inportant function in runoff and erosion control. The beneficial functions of forests are multiple. In a well-stocked forest, as a rule, there is no erosion even down the very steep slopes during heavy rains. The multiple erosion-control effect of the forest is the result of the protective impact of the crown and forest litter. Forest litter, owing to its high permeability and high water capacity enables the quick infiltration of raifall. Forest litter is capable of absorbing 2-5 times more water than its weight in air dry state.

Figure 3. Maximum Speciific Discharge Observed in a Year



Forests prevent sudden surface runoff of water, so that even in the heaviest showers they can decrease the peak flow. This effect of the forest is the result of the impact of the crown of trees and the forest litter. It was shown that, with the removal of forest litter, the runoff increased for 5-10 times. The impact of the forest on runoff regime depends on the choice of species, density of planting, age, grass cover, and forest litter (Zaslavsky, M.N., 1983).

Forest cover also reduces the factors affecting overland flow by increased roughness of slopes increased infiltration of water in the soil, etc. By increasing infiltration, forest cover minimizes overland flow and transforming potential surface runoff into ground water. This underground water moves to springs and the stream bed, and thus the stream does not go dry even in the warmest periods of the year. Consequently, in the Đurinovac Potok and Dubošnički Potok streams the total annual runoff occurs in several events in April, May and October whereas in Lonjinski Potok drainage basin, there mainly is a constant stream flow throughout the year (with some exception as a result of long period of drought preceded by high temperatures in the previous months). Also, by preventing rapid overland flow, forests increase the time of water concentration, which directly reduces the risk of flood peaks.

The indirect effect of the forest reflects itself in the good structure of the soil under permanent vegetation, which increases soil resistance. The increased infiltration capacity of such soils leads to the reduced quantity and velocity of water movement down the slopes. Also, the specific fauna gas the beneficial impact and it improves the structure and the infiltration capacity of the soil.

The results of research confirm that good forest cover in a drainage basin produces a balanced regime of stream flow without larger floods of dry periods. This is very important as dry streams adversely affect bad ecological conditions as well as life and economic activities of the local population. The significance of forest cover should be emphasized in control of soil erosion. Namely, after forest degradation occurs there follow, a more intense erosion process whereby the soil is removed. Erosion loss of the spongey forest surface soil causes the deterioration of the runoff regime from the drainage basin, as rainfall cannot be infiltrated so it runs down the bare, slopes and consequently augments the flood peak. Therefore, forests also affect the regime of runoff by controlling soil erosion.

It can be concluded that soil erodibility factor increased in dystric cambisols in spruce and fir plantations established on beech site. This resulted primarily from the reduced content of total humus in the first 10 cm of soil depth.

The modified character of organic matter did not cause any greater changes of the structural aggregate sizes in the surface layers of the soil, but it affected the stability of structural aggregates by changing the cation composition of the adsorptive coplex and solution. In the fir plantation, the stability of structural aggregates was lowe because of the reduced concentration of adsorbed and soluble calcium, as the ion coagulator. In the spruce plantation, there were no significant changes of structural aggregate stability compared to the soil in the natural beech stand, althougt the soluble and absorbed calcium was also removed from the profile. This probabrly resulted from strong adidification of the soil, influenced by aggressive organic acids. High acidity of the soil activated the trivalent ions coagulators (Fe^{+++} and Al^{+++}) which replaced the removeed calcium in the coagulation of mineral colloids and the linkage of organic and mineral matter. As the analyzed period of the plantation inpact on the soil is only a third of spruce and fir rotations, in can be expected that soil erodibility will be increasing till the and of the rotation.

Soil erodibility factor is not the only factor that affects the amount of sediment yield, which means that its increase is not necessarily reflected on sediment yield. The analyzed spruce and fir plantations are characterized by a high site quality and canopy closure. The canopy in plantations is even berrer than in beech forests on adjacent areas and it is permanent throughout the year. This reduces the kinetic energy of raindrops, which is also a significant factor in the detachment of soil particles and their preparation for transport. Simultaneously, a part of precipitation is retained as interception. If the degree of canopy closure remains permanently, sediment yield will not be higher. But still, more serious erodibility is a potential hazard in case of inadequate forest managment.

In these plantation, management should rely on lower-intensitu felling, with simultaneous introduction of broadleaf species and establishment of mixed broadleaf-coniferous stands.

Broadleaf speacies to be itroduced should primarily be those than can perform the biological accumulation of calcium and that represent a more suitable energy material for soil micro-organisms and for the production of mature humus.

4. CONCLUSION

The results of the research show that forest cover has a considerable effect on the formation of the runoff regime from the drainage basin.

With all the other conditions being equal or similar (rainfall, relief, parent rock, soil) in Lonjinski Potok (70% of the drainage basin area under well-stocked forest) there is a balanced regime of runoff whereas the torrents Đurinovac Potok (39.5% of drainage basin under forest) and Dubošnički Potok (48.5% under forest) have unbalanced regime of runoff. Runoff in those two drainage basin was dis continuous with large intervals of drought and the discharge was mainly in the form of flood waves.

The unbalanced regime is also confirmed by the data on maximum discharge (Q_{max} and Q_{sp}). Average annual height of maximum specific discharge in Lonjinski Potok was 5.1 times lower than that in the Đurinovac Potok and 2.30 times lower than in the Dubošnički Potok drainage basin. Lonjinski Potok dried up rarely (average annual 13.4 days) whereas average annual number days without water was in Dubošnički Potok 121.4 and in Đurinovac Potok 200.2.

All the above proves that forest cover is a powerful means of flood peaks control (water conservation) in the small mountainous drainage basin.

The results of the research showed that the degree of forest cover in hilly-mountainous drainage basins affects significantly the type and intensity of erosion processes, as well as sediment transport.

The specific mean annual transport of total sediment transport in the Lonjinski Potok (70% of drainage basin under well-stocked forest) was 4.5 times lower than in the Dubošnički Potok (48.5% under forest) and 3.5 times lower than in the Đurinovac Potok (39.5% under forest).

It can be concluded that soil erodibility factor increased in dystic cambisols in spruce and fir plantations established on beech site. This resulted primarily from the reduced content of total humus in the first 10 cm of soil depth.

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PLANTING TREES AND RECULTIVATION OF DEGRADED LANDS OF EPS, AS POSSIBLE CONTRIBUTION TO PROTECT ENVIROMENT OF KOSTOLAC COAL BASIN

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Abstract: *Kostolac coal basin consists of open pits coal mines and power stations of 1010 MW; electric energy production reduced cultivable fields turning them into lignite exploitation fields, ash and dross disposals; because of this, Electrical industry is considered as the biggest polluter of the environment in this area. These fields are to be recultivated during coal exploitation and it is particularly necessary to finalize it together with end of the work of these companies. Our answer to this problem is planting with trees according to long–term project.*

Keywords: Kostolac coal basin, ash deposit, barren soil, recultivation

1. INRDODUCTION

On part of Danube from Smederevo to Veliko Gradiste fall into Velika Morava and Mlava. Watershed these two rivers makes Sopotska greda, which in length of cca 60 km is ranging in direction from north to south: from Beljanica mountain to Kostolac's Ireland, in other words Kostolac (which is on 44 43' latitude, and 21 14' longitude). Nature is this territory, which main determinants are Danube and Sopotska greda, plentifully rewarded with black gold – pit coal, so this territory gets its name Kostolac coal field by town Kostolac where is back at 1870 in final slope of Sopotska greda started pit – fall exploitation of lignite, which was transported through Danube.

Kostolac is a city which "swims" in sea of coal-pit and overtakes territory of 1050 ha. The first mine-shaft was open in the bottom of plateau on which, even today are archeological remains of middle ages Branicevo and ancient Viminacium.

Exploitation of pi-coal on these territories is for two centuries skeleton of development of energetic whole Serbia with increase of production and surface exploitation for last two decades, it became a source of big ecological problems, which is result of bad planning and husbandry with this recourse and inobservance of principles sustained development.

For Europe, Danube is traveling way marked as corridor 7, while Sopotska greda range over parallel with corridor 10, where are in ancient time from Viminacium, center of province Upper Mezija, take a main Roman way (Via Militaries) along alluvium Mlava, goes across and along valley Morava to Nais (Nis), wherefrom one arm take part of for The Black sea, and the other for southern areas and Greece.

On the dump of Kostolac coal basin creates specific micro-relief, uneven, like dyne, with lakes and ponds or steep sides with height about a few dozen meters. In that way unorganized and

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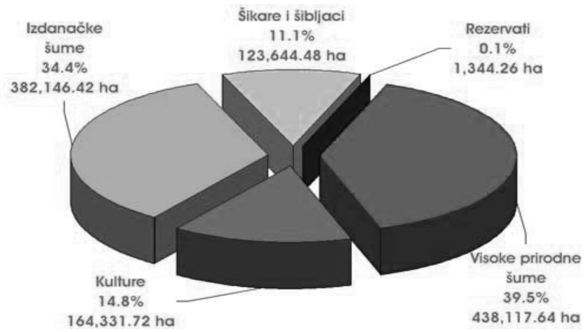
unprotected areas, are exposed to soil erosion process and potential slipping of land, because of that, on that place we should create new ECO-systems which will have big influence on preventing pollutions of environment, and territories will be protected from soil erosion and recultivated land.

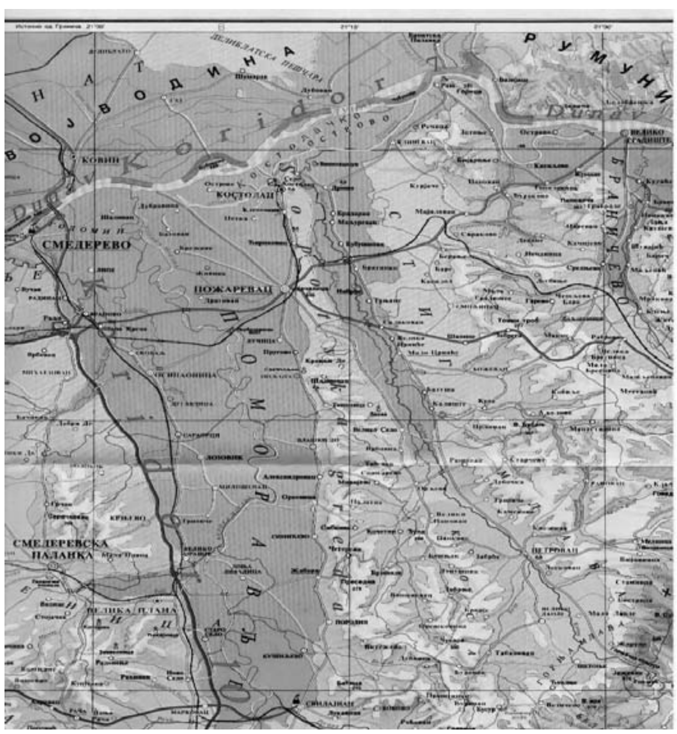
This new barren soil should be made into agricultural and sylvan areas, the land should be given back its original looks, with all that we will get more purified air and recultivated land.

Graphic 1.Wood fond of JP "SRBIJA ŠUME"



From power plants chimney air pollution is big, rivers are polluted by liquid waste like a land which is under plants waste – ashes. All of that should be annulated and be back to environment pure water and land – one of the safest ways is exactly forestry recultivation.

Picture 1. Danube and Sopotska greda – Kostolac coal basin



The structures of this land we can see the best from profile number 4 in f ump of Klenovnik:

Table 1. Analiza: Elaborad D. Salatic, G. Jovanovic

Place of profile		depth in cm	fraction 0,2	fraction 0,2 - 0,02	fraction 0,24-0,002	colloidal alumina	texturing context
barren soil Klenovnik	1	0-20	1,6	51,6	26,3	26,90	sandy
	2	30-50	3,8	59,2	20,7	26,30	Alumina
	3	50-70	3,3	49,5	21,2	26,00	loam
	4	80-100	2,1	50,4	20,9	26,6	

Cave git in all four profiles is representative with 2,7%

Reaction of clay is alkali, and ph in water goes from 8,28 to 8,65 in kci 6,88 to 7,27. Membrane capillary capacity in all 4 profiles is 34,75%, while accessibly eater in plants is 18,5% on the fading limit, which is 17,1% in clay. Mould is any deposal normally below 1%.

From micro-elements Cu is missing, and from macro-elements N and P, that we can compensate by inserting complex NPK mineral fertilizer. Kostolac deposals are secured with accessible Potassium. We can see that the best from agro-chemical analyze of the land.

Table 2. Agrocemical analyze of land

Analyze	Units	barren soil Klenovnik
total N	%	0,053
accesible P2O5	mg/100 gr	43,0
accesible K2	mg/100 gr	29,0
accesible Ca Mg/accesible	mg/100 gr	502,0
pH in water	mg/100 gr	61,4
Ph in KCl	pH unit	8,42
retención capacite	pH unit	7,13
accesible Zn	% V	48,0
accesible Mn	mg / kg	0,6
accesible Cu	mg / kg	2,9
accesible Co	mg / kg	0,0
accesible Mo	mg / kg	0,66
	mg / kg	0,66

Damaging infusion of air in Kostolac are:

a) damaging gases and vapors

b) damaging dusts (ashes and dust – 300 mg/m^3 per day) which produce chronically and acute poisoning of live world regarding if it's bigger of smaller violations of regulatory concentration. People get sick of lung deceases, skin deceases, and vision and from poisoning by bigger concentration the consequence can be lethal.

2. IMPACT OF ASHES TO ENVIROMENTAL POLLUTION

In producing electrical power from coal power plants through out big amounts of ashes and salm, which represents one of the biggest sources of environmental pollution. Percent of ashes recording to unburned coal is 15-30% and represents multiplied environmental pollutioner: It pollutes air with direct emission of fraction from chimneys of by spreading the same from dumps, eater – by rinsing from dumps or refrigerated water and land – by infliction of ashes to surface. Ashes from our power plants to dumps are usually transported by hydraulic ways, by which are created technogenic lands – deposals. Merits of this substrate are: tiny fractions, alkali reactions, very movable on surface (they are liable to eol erosion, with minimal amounts of organic material in them) from unburned coal. Spreading this fractions trough environment the conditions of lives are getting worse and health of people who lives in that kind of environment, which you can see from the next analyses:

Table 3. Sized distribution of particle from ash deposit

Distribution of particle do 0,060 mm	in %
0,060 – 0,075	60,72
0,075 – 0,090	2,75
0,090 – 0,120	7,50
0,120 – 0,150	5,50
0,150 – 0,200	15, 50
0,200 and more	4,00

Table 4. Chemical properties of ash

$SiO2$	-	47,14 %
$Al2O3$	-	24, 21 %
$Fe2O3$	-	11,08 %
CaO	-	8,76 %
MgO	-	2,26 %
$SO3$	-	1,62 %
S	-	0,14 %
$NaO2$	-	0,25 %
$K2O$	-	0,83 %
$TiO2$	-	0,18 %
$P2O5$	-	0,03 %
annealing	-	3,5 %

Power plants “A” and “B” in Kostolac work with 4 blocks, with all integrated power of 1010 MW, during one year they spend 9 000 000 tons of coal and as nusproducts they through out from 1,7 – 2,5x10 9 ashes and salm, which are mixed with water in relation of 1:15 transported to dump, on the middle Kostolac's Ireland, beside the town of Kostolac. Dump of ashes is momentarily grist depth or in better words height of 80 meters, and overtakes surface of about 210 ha and it's separated to 3 cassettes with its surface of dust and salm. One of cassettes is active, and the other two are spare. Cassettes cyclical change their roles in two – three years. In active cassette is temporized mixture of water and coal pulp (1”15) which because of big amount of water is always under water mirror. Spare cassettes cca 140 ha are dry and accessible to eol erosion, how fraction of dust and very small (over 60% are smaller that 0,06mm), they are under influence of wind (Kosava and boreas (northern) ehich blow out annually about 100 days), they spread around dust and salm in distance of 5-10 kilometers and even more around the ash – hole. Effect of eol's erosion on dumps can take away during the year coat of salm from 30-50 cm, if the dumps do not teat projects which is usually the case, nevertheless the surface of dry spare cassettes 140 ha with simple math which is gained that winds commutate into environment from 840 000 to 1400 000 tons of dust.

Spreader ashes partly is detained on natural discouragements trees and plants, and objects which man build: houses, fences, wind protecting cordon but mostly are in the ground and in the water. The problem is when dust and slam precipitate on agricultural cultures, practically they became unsafely for human and animal nutrition. Citizens very slowly abandon their houses which are besides the ash dep osit of power plant Kostolac, because their health is jeopardized by lung and cancer deceases.

Because of all that above for dumps of ashes and salm we must find adequate solutions, and that is in planting grass and a forestation of dumps, but also their environment. On the dumps temperatures on the surface in summer goes to even 65 C, which effects on choices of plant veil.

Primal flora by the end of storage on cassettes, besides algae's and lichen is:

1. Am aranthus blitoides 2. Am aranthus albus 3. A triplex lacinista 4. Xanthium strumarium 5. Cheno podium botys 6. C orispermum byssofolimu 7. C ynodon dactilon 8. P oligonum persicaria 9. P oligonum lapathifolium 10. S etaria glauca	This flora is characteristic for sands, overburdens and dry soils.

Picture 2. Cutting of reclaimed area on cassete „A"TE Kostolac 8. VII 2001

3. RECULTIVATION OF ASH-HOLE AND THEIR ENVIROMENT

Biological correlation of dust and salm on dumps power plant "Kostolac" can be carried out by planting grass: Fesuca rubra, Medicago sativa and Brasica napus oleifera in amount of 80 kg per ha. Previously it should be done cultivation of dust and treating of fertilizer N:P:K – 15:15:15 – 500 kg per ha, then seeding, seed covering, planting territory and daily watering for the next two months.

Planting of protection cordon will take in cloned willows, locust tree and,

And like whit willow, which we can find like a spontaneous populous category on ashes with single cases of withy.

Euro-american willows are planted in Kostolac on ash-hole in pitfalls 50x50cm without fertilizing, one year tree 1/1 and trees are developed nicely, they were healthy and had good fat (1,2-2cm) and altitude diameter (1,2-1,5m) annually. Planting of willows to ash-holes 70-80 cm depth and diameter of 45 cm with fertilizer 0,4 kg by piece NPK gives bigger wood mass of 70 m3 per ha. In that way electro-filter ashes can be convenient substratum for planting willows and specially utilized for production of trees for paper and cellulose industry. Willow in short behavior (10 years) gives high increment of wood mass 30-40 m3 per ha annually.

Planting trees on dumps is not significantly just because of attachment of dust, it's more significantly because of production of oxygen, which is in short supply, because of process of oxidation of combustion of coal. Consumption of Kostolac power plant's annually is 5700 000 t of oxygen. For combustion of 1 kg of oil spends 0,6 kg of oxygen and 1 ha of wood make about 11 tons of oxygen daily which means that if we want to keep ecological balance we must plant in our environment at least 500 ha of woods. We espier method of recultivation. Edaf's condition, water system in depth , deep planting and good aeration of ashes, effect positively to possibility of intense nourishment of willows, which don't get behind of cultures breed on the most optimal soils. That indicates that dumps of ashes can successfully be used as a substratum to life fast growing willows, so it can achieve ecological effect, with adequate technological and constant irrigation.

Planting trees, spreading ashes can be stopped for 2-3 months, and with planting trees for 2-3 years. Combination these two methods we can achieve good results, and dumps with planted trees have dominant part in production of oxygen, which was spended during combustion of coal.

Therefore, it's not enough to plant trees on dumps of ashes to protect living environment of people, we need to plant wider environment. To protect the whole territory which is jeopardized by combusting, it is needed to build up about 500 ha of forest to compensate consumption combusted oxygen during the process of combusting coal and to protect people's living environment. To plant this territory is impossible, we don't have that kind of territory that we can use. That means that this ecological catastrophe can be extenuate by planting trees and can not be annulated.

Woodland holding "Northern Kucaj" Kucevo have 65000 ha under wood. WH Pozarevac with 8410 ha and all that territories under woods are not enough to recompensate consumption of combusted oxygen during the process of combusting of coal. In township of Pozarevac woods and woodland are 3996 179, which means that woodiness is about 9%. This is very little, woodiness of Serbia is 27,4%. Woodiness of state forests are 60,8% (1286 ha) overgrown and 39,2% (825 ha) uncover grown land, which is very negative aspect. Lawns for planting trees are 451 ha and on that land we plant trees every year about 60 ha.

Potential lands which can be planted partly propitiate grays pit-coal and smoke from power plant's chimney. We can achieve a big influence of wood on: fraction sedimentation of dust, preventing noise, production of oxygen and spending Co2 on preventing wind blows and creating convenient macroclimate conditions.

Forests have priceless importance for protection of human environment, because with their rooted system stabilized the ground, preventing erosion, stabilize dust, amortize erosion strength of rainfalls and contribute changing of micro-climate, flora and fauna and create oxygen which people needs.

APPEAL: ONE MAN – ONE TREE

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HERBACEOUS PLANT USAGE IN THE RECLAMATION OF COPPER MINE TAILINGS

Dragana RANĐELOVIĆ[1]

Abstract: *Copper mine tailings are considered as one of the hardest habitats for plant growth and development due to their high acidity, heavy metal toxicity and nutrient deficiency. A successfully established herbaceous cover is often the first step in the rehabilitation of these areas.*

Reclamation success depends of many factors, such as adequate site and ground preparation, usage of chosen plant species or their tolerant ecotypes, seeding technology and management/aftercare measures. Mistakes made at any of these points may have an adverse effect on the total reclamation effort.

Reclamation goals are usually limited by adverse environmental conditions and they are in general oriented towards erosion control and creation of sustainable plant cover.

This paper points out some modern patterns in copper mine tailing reclamation, basic moments which need to be considered when it comes to using the herbaceous plants, and discusses the examples from Serbian practice.

Key words: reclamation, copper mine tailings, herbaceous plants

1. INTRODUCTION

The origin of tailing material is decisive for the success of plant development. Tailings are an inert matter consisting of ground rock, a mixture of lithologic components of the geological column disturbed during ore exploitation.

Tailings differ depending on the type of mining and they include the capping material and the waste from preparation (flotation waste). Their toxicity also differs depending on the origin and it depends mostly on the presence of pyrite.

The complexity of the problem and approach to spoil bank rehabilitation in copper mines depends on whether it is an area with the complete ore processing and with air pollution resulting from smelting, or it is the area where the ore excavation and removal ceased, i.e. the area where mining activity stopped and the land is reinstated.

Rock material is impermeable, so the slope inclination of spoil banks accelerates the surface runoff of loose material, which results in galleys. The land itself, either on flat parts or on the slopes, is exceptionally erodible.

One of the basic goals of rehabilitation by herbaceous species is erosion control, so to this aim, herbaceous covers are formed with the largest possible degree of coverage. Along with erosion control, they also represent the initiation of the site revitalisation.

Once the site has been stabilised, natural processes lead to the more complex plant cover, primarily in the sense of the colonisation by the resistant species from the adjacent sites, and then to the formation of the more mature stages.

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2. GROUND PREPARATION AND SEEDING TECHNOLOGY

One of the basic preconditions for the development of grass cover is the adequate ground preparation. Most often this step has the decisive effect on the rehabilitation success in general.

As the tailings are a biologically sterile substrate, during the preparation for landscaping, the soil should be biologically activated by the introduction of a sufficient quantity of organic matter and vital micro-flora and by correcting the unfavourable pH value of the substrate.

The soil acidity, the reduction conditions and the high concentrations of heavy metals restrict the abundance and the diversity of living beings in the tailings. The soil is characterised by a very heterogenic composition, different particle size distribution and poor water-air regime. An additional problem is the fact that wetting the pyrite tailings leads soon to additional land acidification, which affects the availability of nutrients and heavy metals to the plants. It is also characterised by the migration of acids, heavy metals or salts towards the ground surface.

The preparation of the soil for the rehabilitation in such terrains can be performed by several methods: by overlaying a fertile soil layer, by the use of treated municipal sewage sludge as the source of organic matter, by the use of mow cuttings, i.e. green biomass which should, by its decomposition, amend the characteristics of the substrate.

If the overburden has been selectively removed and if the surface fertile layer has been conserved, the process of soil preparation is less complex and far more efficient than in the case of nonselective deposition, when the fertile layer is permanently lost.

Regardless of the type of degradation in the copper basin, by all means the maximum attention should be devoted to the adequate revitalisation of the soil and to the elimination of the limiting factors for plant development. Some of the measures for the amendment of the qualities of such substrate are also calcification and the introduction of different inorganic and organic fertilisers (NPK fertiliser, municipal sewage sludge, mowed grass, etc.). In some cases, it is necessary to overspread a fertile surface layer, which requires great financial investments, and also the finding of the adequate quarry for soil excavation.

For the success of grass cover establishment and the high percentage of the coverage, it is very important to select the adequate method of seeding, especially on the steeper slopes of spoil banks or at the inaccessible sites. Sowing can be performed manually, or from the air (air-seeding), and recently hydro-seeding has become a topical method in the rehabilitation of degraded areas

3. THE SELECTION OF SPECIES

A significant issue in the early stage of reinstatement is the selection of the seeding mixtures. In the recultivation programmes, they are usually heterogeneous. It is known that the mixtures consisting of several species, because of the greater diversity of genotypes, are much better adapted to the complex environmental conditions than the homogeneous ones. Some herbaceous species are characterised by fast growth, they produce a high quantity of biomass in a short time, while other species sprout and grow more slowly and can survive for a longer time at the place where they were sown. The species differ also by their tolerance of drought and frost, and also by their resistance to diseases. In the heterogeneous mixtures, in cases of depletion of one species, due to some unfavourable site factors, the other species from the mixture can take its place.

Among the herbaceous plants, grasses (fam. *Poaceae*) are the most widely used plants in the rehabilitation programmes. They produce a great quantity of biomass, they have hairy root systems which stabilise the soil, so they have an important role in erosion control.

The species of the family *Poaceae* have a wide ecological range, and some grass species are well adapted to infertile, dry and acid soil, such as is often found on the spoil banks of metal mines. In the area of Bor and Majdanpek Basin, the grass species *Festuca rubra* and *Lollium perene* are applied with success.

The legumes belong to the family *Fabaceae*. They can use the atmospheric nitrogen, supported by the symbiotic nitrogen-fixing bacteria which live in the root nodules of these plants. A healthy population of legumes is essential for a successful revegetation, because nitrogen-fixing plants have proved to be an initial force for the acceleration of soil development and for further success of plant development.

The studies of primary succession show that, along with the accumulation of organic matter, an increase of the quantity of available nitrogen is of high importance for ecosystem development. [4]

A very good degree of coverage on the recultivated plots in Bor and Majdanpek was achieved by the species *Lotus corniculatus* and *Trifolium repens*.[1]

The species of annual or perennial herbaceous plants which belong to the so-called 'wild' or native vegetation can also be used in the rehabilitation. The research shows that a great potential can be ascribed to the species which appear as pioneers on the degraded sites of mine spoil banks. Most often, they are the species of the surrounding natural communities, and they are adapted, or can be adapted, to the exceptionally unfavourable site conditions of mine spoil banks. Often these plants are indicators of acid sites, and they have the capacity of tolerance or hyper-accumulation of some heavy metals, as well as the resistance to temperature extremes. Thus the species *Ephilobium fleicheri* in the form of individual clusters was observed on the Bor mine tailings invading the slopes of the spoil banks.

The use of ecotypes tolerant to heavy metals (for example the species *Agrostis capillaris* or *Festuca rubra*) has been for already several decades a method of successful landscaping of spoil banks remaining after the exploitation of mercury, zinc and copper (Todorff *et al*., 2000). Direct seeding of tolerant cultivars is a sphere in which further advancement is expected, with special emphasis on the selected species from subtropical zones, such as *Eragrostis curvula* and *Cynodon dactylon*.

It is interesting to mention the example from our domestic practice when on the Bor copper mine tailings the allochthonous species *Eragrostis curvula* was tested for the possibility of establishment of erosion-control lawn. The species was exceptionally resistant to the substrate acidity, and on the gentler slopes, it reached a high degree of coverage, even in the conditions of occasional blowing of sulphurous smoke from the ore processing plants.[2]

The selection of species and their percentage in the mixture to be used depends on many factors. They are, by all means, the characteristics of the substrate (loose or compact, higher or lower acidity, potential additional acidification, etc.), the conditions prevailing on the site (water regime as one of the most important factors, slope, exposure, altitude, frost, wind intensity, dominant wind in the areas with air pollution), but also the characteristics of the species (sprouting energy, resistance to environmental conditions, tolerance of lower pH value, tolerance of heavy metals, high capacity of regeneration, developed root system). The percentage of the species in the mixture is also important for the establishment of the herbaceous cover and for its survival after growing up. It is especially important to pay attention to the legume percentage in the sowing mixture.

In the last years, attention has been focused also on the long-term effects of the rehabilitation, so it is recommended to avoid the aggressive species (such as *Festuca arundinacea*), which crop out very soon and amend the erosion problem in a short time, while the less aggressive species (*Eragrostis curvula, Lotus corniculatus*) allow the subsequent colonisation of other species, by which the diversity of the site is enriched.

By the selection of the species with the capacity of accumulation of heavy metals, it is possible to some extent to remove their concentration from the soil, which improves the conditions for other vegetation in this area.

In the area of Bor Basin the possibility of grass species that accumulate heavy metals was tested, in the aim to point to the most feasible species which could be applied in the process of the soil phyto-remediation. Altogether 9 species were tested for the degree of iron and copper accumulation. The species *Arrhernaterum elatius* and *Festuca arundinacea* [3] were selected as potential hyper-accumulators of heavy metals, iron and copper.

The research of phytoremediation of the soil in Bor Basin has lately become very topical, in harmony with modern tendencies in the world. Taking into account the complexity of this issue, it is necessary to continue the research and to identify a wider spectre of species with high phytoremediation capacity.

4. TENDING MEASURES

The processes of plant cover establishment on such soils are mostly very long, if not supported by the anthropogenic factors. Consequently, one of long-term goals of rehabilitation is to ensure the sustainability of the established vegetation.

The dynamics and the time of seeding should be adapted to the climate conditions of the region, particularly when it is taken into account that the stripped areas are subject to more intensive warming, desiccation, freezing, etc. Sometimes it is necessary to foresee the quantity of water for additional irrigation during the dry period, or the spreading of mulch to protect the plants against freezing. The best periods for seeding are spring or autumn.

Finally, the appropriate aftercare measures (primarily irrigation, then also fertilisation, and sometimes mulching to prevent the runoff on the steeper slopes) during a period after seeding enhance the establishment and sustainability of the plant cover at such sites. In some cases, to support the vegetation cover in general, it is necessary to apply the regular tending measures and repair seeding, which considerably increases the financial costs. Subsequent fertilisation, care about the permanent presence of nitrogen-fixing plants and occasional mowing are some of the basic measures of tending in the recultivated areas.

5. CONCLUSION

The results of domestic and foreign research show that, although it is an exceptionally unfavourable environment, biological rehabilitation of copper mine tailings is possible. The experience shows that it should begin by the establishment of the initial grass cover which should prepare the soil for the colonisation of other plant species.

Based on presented data, the following methods of rehabilitation of opencast mines by herbaceous species can be recommended:

- rehabilitation by resistant grass species which proved to be successful in the landscaping of such areas;
- introduction of grass species which proved to be resistant in landscaping of copper mine tailings, but on other territories, testing and utilisation of resistant genotypes of the species which proved to be resistant in landscaping of copper mine tailings;
- rehabilitation by favourable native species from natural vegetation
- testing and utilisation of the mixtures of resistant genotypes of the species which spontaneously colonise such areas;
- testing and utilisation of the species which have phytoremediation characteristics

The success of the early stage of rehabilitation depends on the combination of all the above mentioned factors, which additionally points to its complexity and to the required professional approach. The mistake in any of the above items can lead to the significant decrease of the results, sometimes even to a complete failure.

The latest rehabilitation technologies are directed to the establishment of self-sustainable plant communities on such areas, through the natural and artificial selection of the resistant populations and the acceleration of the natural processes of plant colonisation, as well as to phytoremediation, i.e. the use of plants in the substrate reinstatement and creation of favourable conditions for enrichment of diversity on such sites.

The aspect of the use of native pioneer herbaceous species in landscaping of such areas has not been dealt with by the domestic studies to date, so this study points to the importance of further investigations in this direction.

Copper mine tailings are very unfavourable sites for plant development, which makes them a challenge to all researchers in this field, therefore the success of their rehabilitation deserves the additional significance.

The new, cleaner technologies of ore exploitation and processing will result in the lower degree of environmental pollution, which will enable a more successful landscaping of such terrains and further development of the research in this sphere.

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REHABILITATION OF THE MUNICIPAL AND INDUSTRIAL DUMPSITE BY THE ESTABLISHMENT OF POPLAR PLANTATIONS

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Abstract: *The rehabilitation procedure of the municipal and industrial dumping ground was investigated in the MU «Jalija-Leget-Turijan», starting from the creation of the dumpsite, reconstruction proposals, methods of solving, works, survey of costs, to the establishment of poplar plantations. A compartment of the above Management Unit is adjacent to the industrial zone of the town Sremska Mitrovica, and for this reason it served for both industrial and municipal waste tipping. The conditions for the rehabilitation were satisfied when the rental agreement for the land for industrial dumpsite expired, between FE «Sremska Mitrovica» and the Sugar Factory in Sremska Mitrovica. Great effort was made and significant financial means were invested. This paper points to the significance of this undertaking, both from the production and from the ecological and aesthetical aspects.*

Key words: waste, dumpsite, poplar.

1. INTRODUCTION

Forest Estate «Sremska Mitrovica» is within the SE «Vojvodinašume» and it manages the forests of Ravni Srem on the area of about 42,500 hectares of which 37,500 ha is covered by forests. Forests of common oak, narrow-leaved ash and hornbeam cover the area of about 30,000 ha. Intensive plantations of poplar clonal varieties occupy the area of about 6,000 ha.

Considerable results were realised thanks to the professional, conscientious, sustainable and integral management of autochthonous forests and intensive plantations. In the past fifty years, timber supply in the Ravni Srem forests has been doubled. The construction of hard-surface forest road network enables the works on permanent forest improvement in addition to other necessary preconditions.

During the last 5-6 years, the rehabilitation of the terrains which were not used for forest production went along with the regular tasks. Most often they were the quarries of soil, dumpsites and large depressions in which water remained for a long time. The rehabilitation required persistent work and significant financial means.

The desire for better utilisation of natural site potentials and for a higher production of wood volume, together with the simultaneous ecological and aesthetical effects, was an impetus for the increase of forest area by the rehabilitation of the above degraded lands and by planting forest trees.

The rehabilitation was performed on a number of localities, total area about 100 ha, of which the most significant is at Leget, i.e. in the second compartment of the above Management Unit.

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2. WASTE PIT CREATION AND THE DECISION ON THE REHABILITATION

The forests in the vicinity of settlements are very often subject to negative anthropogenic effects. They are especially endangered by waste tipping, both of the municipal and the industrial refuse. This happened also in MU «Jalija-Leget-Turijan» which extends along the bank of the river Sava, downstream of Sremska Mitrovica, as far as the village Jarak.

A part of the second compartment of the above MU, area 15 ha, was leased for the period of 15 years by the Sugar Factory in Sremska Mitrovica for the tipping of the saturation silt and limestone. The pulp and paper factory «Milan Stepanović Matroz» during the great fire dumped a large quantity of poplar bark on the area of more than 5 ha. In addition to the above industrial waste, there was also a large quantity of various municipal wastes. The conditions for the rehabilitation were satisfied when the rental agreement for the land for industrial dumpsite expired, between FE «Sremska Mitrovica» and the Sugar Factory. The reconnaissance showed that it is necessary to remove 12 - 15,000 m 3of inorganic waste. The first idea was to place the waste in the ditches excavated for this purpose, sufficiently deep to support the afforestation. According to the offer for the terrain preparation, the removal of inorganic waste cost was 2,988,000.00 dinars for the area of 18 ha. The report dated 2nd Oct 2002 states that the cost of this undertaking is 5,533 DM/ha, which was, for that time, a too high and unfeasible cost. However, fortunately this problem was not discarded. The works started in 2003. By the persistent and systematic work, after three calendar years and four afforestation seasons, the entire area was restored. The realised undertaking has a high productive, ecological and aesthetical significance.

3. WORKS ON THE SITE PREPARATION AND ESTABLISHMENT OF POPLAR PLANTATIONS

In a part of the compartment there was a thinned clonal poplar plantation which was harvested in January 2003. The plantation was very thin, and a part of trees were damaged by the vehicles which carried the refuse. For this reason, the plantation aged 24 and 25 years, on the area of 14.36 ha produced only 1,589.96 m3 of wood products, or only 110.72 m3/ha. The inorganic waste in the plantation had to be collected and removed from the productive area. A part of the site had to be levelled by a bulldozer. The works started immediately and in March 2003 the area of 15.15 ha was prepared and reforested. Reforestation was performed by planting the poplar clonal varieties, type 1/1, planting space 5 x 5 m. The expenditures were recalculated by the mean € exchange rate of at the end of each month settlement. The cost of preparation and reforestation of 15.15 ha was €24,269, i.e. 1,601 €/ha.

The successful output was a sufficient impetus for the continuation of the works. The works on the gathering and removal of inorganic waste and site levelling were continued. In March 2004, 6.28 ha were reforested, in November of the same year – 8.12 ha, and in December 4.74 ha, i.e. altogether 19.14 ha in 2004. Reforestation was performed with poplar clonal varieties, planting space 5 x 5 m. The total cost was € 33,272 or 1.378 €/ha.

After the reforestation, a small area still remained, but it was very unfavourable for rehabilitation. They were the hills of poplar bark brought from the pulp factory «Milan Stepanović Matroz» with admixed inorganic material (stone, concrete). A significant part of the bark was burnt, and there was a great quantity of ash. There was also some sand which was used to cover the bark to prevent self ignition. Despite these circumstances, it was decided to continue the rehabilitation. A part of the humified bark was removed by the interested users, the site was levelled and then reforested. 2.63 ha was reforested in March 2005, and 5.84 ha in December of the same year, i.e. altogether 8.47 ha. The reforestation was performed with clonal varieties of poplar, type 1/1, planting space 5 x 5 m. The cost of these works was €19,061 or 2,251 €/ha in 2005.

Total area of land rehabilitation and reforestation by the establishment of poplar plantations covered 42.76 ha. The cost of this undertaking was € 76,592 or 1,791 €/ha. Although this is a high amount, the comparison with the offer for site restoration and removal of inorganic waste dated 2002 shows that the above price of works is more than acceptable. The scale and dynamics of the reforestation are presented in Table 1.

Table 1. Survey of afforested areas and consumed rooted cuttings.

Afforestation season	Area (ha)	Spacing (m)	Number of plants			
			Populus x ea I-214 (pcs.)	Populus x ea Cl.Pannonia (pcs.)	Populus deltoides (pcs.)	Σ (pcs.)
2002/03	15.15	5x5	5606	-	460	6066
2003/04	6.28	5x5	-	1000	1510	2510
2004/05	15.49	5x5	4300	394	1512	6206
2005/06	5.84	5x5	-	-	2334	2334
TOTAL:	42.76	5X5	9906	1394	5816	17116

The plant survival and the afforestation success were good, but it still required some repair planting (Table 2). The survey of repair planting is presented in Table 2.

Table 2. Survey of the scope of repair planting in the plantations

Afforestation season	Area (ha)	Number of plants			
		Populus x ea I-214 (pcs.)	Populus x ea Cl.Pannonia (pcs.)	Populus deltoides (pcs.)	Σ (pcs.)
2003/04	2.46	985	-	-	985
2004/05	2.12	-	-	848	848
2005/06	2.20	-	40	837	877
TOTAL:	6.78	985	40	1685	2710

Soil mapping in MU «Jalija–Leget-Turijan» shows that 50% of the area (365.50 ha) belongs to the systematic unit alluvial semigley (Ivanišević P. et Živanov N., 1987), i.e. one of the best soils for the establishment of plantations of poplar clonal varieties. However, the anthropogenised alluvial semigley prevailing in the second compartment of the above MU results from human impacts. The measurements by the random sample principle in the established plantations of poplar clonal varieties, presented in Table 3, point to the good characteristics of this soil for the production of wood products.

Table 3. Average values of mean diameter of the clones used in the rehabilitation

Clonal variety	Plantation age (years)	Mean diameter 1.30 m (cm)
Pxea cl. I-214	2	9.7
Pxea cl. Pannonia	3	10.6
P. deltoides	3	12.0
Pxea cl. I-214	4	15.6

4. EXPECTED RESULTS IN THE ESTABLISHED PLANTATIONS

As these plantations are of medium density, the thinning is necessary also for biological reasons. It is expected that it will be biologically desirable at the plantation age of 5 - 7 years. The expected intermediate yield and income is presented in Table 4. The expected intermediate and principal yields are estimated based on the previous yields on similar sites, with similar technologies and poplar varieties.

Table 4. Expected intermediate yield and income

Product	Yield quantity (m3)	Price €/m3	Income (€)	Income €/ha
Logs cl. poplar I cl.	40	35.00	1400.00	
Logs cl. poplar II cl.	75	27.50	2062.50	
Technical billet m.l.	600	25,00	15000,00	
Pulpwood m.l.	785	24.00	18840.00	
TOTAL:	1500	24.87	37302.50	872.37

Table 4 shows the data on the total established plantation area of 42.76 ha, which means that the expected yield was 35.08 m3/ha and the expected income 872.37 €/ha.

This income is sufficient to cover the costs of felling, conversion and transport of the produced wood products.

The principal felling is expected at the plantation age of 20 years, considering the biological-technological and economic aspects, which are decisive for the duration of the production cycle (Pudar Z., 1985). Table 5 gives the data on the expected principal yield and income.

Table 5. Expected principal yield of 20-years rotation

Forest Product	Yield (m3)	Price (€/ m3)	Income (€)
Logs cl. poplar F	4,000	65.00	260,000
Logs cl. poplar L	3,875	50.00	193,750
Logs cl. poplar I	1,875	35.00	65,625
Logs cl. poplar II	1,500	27.50	41,250
Pulpwood m.l.	3,750	24.00	90,000
TOTAL:	15.000	43.38	650.625

Evidently, the principal yield and income justify the epithet «principal» on the total area, and none the less imposing are the results per unit area. The expected principal yield of 350,80 m3/ha, based on the estimated percentage of wood products, should result in the income of 15.215,74 €/ha.

Evidently, based on the aspect of production, the decision on land rehabilitation was justified.

5. CONCLUSIONS AND DISCUSSION

The estimated income from the intermediate yield amounting to €37,302.00, and the principal yield amounting to €650,625.00, increased by the potential income from "carbon" credit of

€84,000.00, altogether €771,927.00 are for about ten times higher than the dumpsite rehabilitation costs by the establishment of poplar plantations. (€76,592.00).

The above revenues are sufficient for the covering of the costs of plantation tending and protection, for the production of timber products from the intermediate and principal yields and for profit making.

In addition to the direct economic benefits, there will be a series of ecological and aesthetical effects, the value of which is very difficult to express numerically, and it is still impossible to transform them into the revenue. The awareness of their significance for human life is a sufficient reward and a motivation to continue such activities..

The established poplar clone plantations are the fast-growing plantations with a high wood volume production. The fast growth and the high wood volume production have the decisive influence on the revenue, but also on the ecological effects. From the aspect of production, but also from the ecological aspect, the advantage is given to the tree species and stand types which produce the maximal yield of wood volume (Vučković M. et Maksimović M., 2003). The established plantations on the restored land at Leget, 2nd compartment are expected to produce, based on the high production of wood volume and high ecological effects, such as: CO2 fixation, mitigating the greenhouse effects, production of oxygen, lowering the wind impact, mitigating the climate extremes, higher yield on the neighbouring agricultural areas, favourable effect on water regime, etc.

Based on the OUN Protocol on climate changes adopted in the Japanese town Kyoto in 1997, in addition to the global contribution to mitigating the greenhouse effect, some concrete revenues can be obtained by selling «carbon» credits. Potentially the income of about €84,000 can be obtained for the expected wood production in the intermediate and principal yields of altogether 16,500 m3 and fixing of about 10,500t of carbon dioxide or 2800 t of carbon (the value of which is at the moment about 30€ per ton).

In addition to its economic significance as a fast-growing woody species of high productivity, as well as other ecological effects (storing of carbon and release of oxygen from CO_2, noise isolation and shelterbelt function), poplar is among the rare woody species, intensively used in phyto-remediation of soil and ground water. Phyto-remediation, according to the US Environment Protection Agency (EPA, 2000), is a series of methods and technologies in which plants are applied for site decontamination. The specificity of poplars is the fact that their entire life cycle is narrowly related to water. Their root system has high plasticity which enables it to follow the changes of ground water level, and simultaneously to absorb great quantities of water. The high intensity of transpiration of up to 1300 litres per day (Gatliff, 1994) causes the ascendant course of water in the soil and prevents the washing of contaminants to the lower layers and their migration by ground waters. The most frequent contaminants which can be treated by the phyto-remediation systems are the nutrients (N, P, K), organic compounds (pesticides, VOCs) and some heavy metals (zinc, cadmium and nickel). The restored land extends between the fertile agricultural land and the river Sava, length about 2 km, width on average about 200 m, so on this area poplar plantations can prevent the washing of the above contaminants to the river Sava. The asphalt road constructed in MU «Jalija-Leget-Turijan» passes through the second compartment in the length of about 1 km. This road is used for all works in MU and also by fishermen and hunters. It is also the best access road to the Monument established in 1923 to the soldiers of Timok Division who were killed in the battle at Leget on 06.09.1914 (Prica R., 1986). Not long ago, all the people had to pass through the dumpsite and now they walk through well-tended poplar plantations. The aesthetical effect has its full expression.

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SOME ASPECTS OF RE-CULTIVATION OF STONE QUARRIES

Iskra VASSILEVA, Nora LOZANOVA[1]

Abstract: *Extremely difficult conditions of growth and development plants upon termination of stone open cast m ining exploatation create great problems of the m ining,s biologigical recultivation which are difficult to resolve.*

Based on i solation o f se parate t ypes o f growth con ditions both na tural an dantropogenic spreading of plants over the period of more than 20 years isinvestigated.

Key words: stone open cast mining, recultivation, plants.

Open cast stone mining for industry and construction entails radical changes in the environment, leads to the emergence of technogenous consequences, under which the conditions for plant growth and development get drastically violated. Recovery of these areas is a hard-to-implement activity. The existing conditions for vegetation growth and development after the technical re-cultivation do no t enable treatment of the area as a w hole. These circumstances, which are different for the different parts of the quarry, make it necessary to identify specific types of quarry vegetation habitats under specific conditions and naturally a specific approach to the resolution of the problem.

In some of our previous papers we have presented in detail the philosophy underlying the categorization of quarry vegetation habitats. Generally speaking, the following groups of quarry vegetation habitats have been detected on the borrow habitat of the open cast stone quarry: rocky, skeleton and earth borrow habitat.

Two types of vegetation habitats belong to the group of **rocky habitats**: **of the borts** habitats (vertical and inclined) and **steps and platforms site** (horizontal and slightly inclined). Thes e are habitats featuring the hardest conditions for biological accommodation. The incorporation of the borts habitat in the surrounding landscape may be achieved through the methods of vertical vegetation planting or through accommodation of rockphilous vegetation in the cracks or specific planting locations after blasting of the rock massif at specified points. Re-cultivation of the stairs and platforms in the rocks might be performed in trenches and holes or after the complete covering up of the platform.

The following species might be assigned to the group of **skeleton** vegetation habitats: **talus** habitats (earth-skeleton and skeleton-earth) and **waste bank habitats** (earth-skeleton and skeleton-earth). These are the vegetation habitats at the different parts of the taluses formed in the quarry. Assigned to the same group are also the delluvial embankments, as well as the waste banks and landfills formed as a result of the exploitation. In the case of the earth-skeleton habitats the biological intake is preceded by ameliorative actions, while in the case of skeleton-earth habitats the biological acceptance is performed through immediate accommodation of vegetation.

The group of earth-stratum vegetation habitats comprises the following types – la ndfills, road lanes, embankment dumps and right-of-way strips. The landfills, road lanes, embankment dumps etc. represent piling of soil substrates produced in the course of depletion of the surface

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cover. These are earth masses, mixed with stem residues, roots, stones of different sizes etc. Their biological re-cultivation is preceded by removing of the admixtures, leveling etc. The right-of-way strip is a habitat with distorted soil cover adjacent to the quarry. Different ways of re-cultivation are applied depending of the thickness of the soil layer.

The characteristics of the quarry habitats may be supplemented with information about the objectives and direction of biological re-cultivation. The designation-based names of the habitats would look as follows:

- Habitats for vertical vegetation planting;
- Habitats for grass planting;
- Habitats for bush planting;
- Habitats for tree planting;

At the background of the thus identified habitats, accommodation of vegetation has followed two approaches – natural and man-made. In both bases there has been a certain rehabilitation effect, depending on the nature of the habitats.

With a view to establishing the rehabilitation effect surveys have been conducted of specific habitats in three sites. All the three sites are situated in the area of the *Pancherevo* Dam, i.e. under equal physical-geographic and climatic conditions.

In the first site (Fig. 1) human intervention for accommodation of vegetation in skeleton-stratum waste bank habitat has been studied on a waste bank formed in the process of construction of the equalizing basin of *Kokalyane* HPP. The digging works were completed in 1951, the slope gradient is from 20-25% to 65-70%, the exposure is southwestern and the altitude 600 m a.s.l. The length of the waste bank is 150m. The waste bank had been afforested with *Pinus nigra* Arn. and *Rubinia pseudoacacia* L. as pure species and mixed stand, whereat the existing gullies have been covered with by soil substrate. The afforestation had been performed in the form of small terraces, shaped by means of 40-50 cm wide fencing blocks installed at a distance of 1.00 - 180 cm from each other as measured down the gradient.

Fig.1. First site a) After 20 years b) After 40 years

At a later stage *Quercus robur* L, *Viburnum lantana* L, *Populus tremula*, *Ulmus campestris* L (*Carpinus betulus* L) have gradually set in one by one in a natural way. *Dactylis glomerata* L, *Hypericum perforatum* L, *Agrostis vulgaris* With , *Euforbia cyparisias* L etc. are spread under the canopy.

The second site (Fig. 2) is an embankment dump, resulting from the pit of the "navigation canal" immediately adjacent to the wall of *Pancherevo* Dam. The total gradient of the embankment dumps is quite large and at places goes up to 120%. The vegetation has set in by itself in the more inclined sections of the embankment dump, on the small terraces, which have remained from the working platforms and in the heel of the slope, where a train-type waste bank of earth-skeleton substratum type has emerged during the stabilization processes.

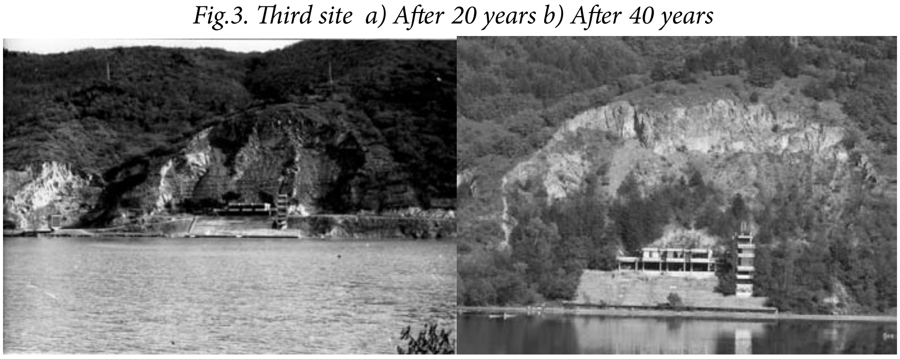
Fig.2. Second site a) In the beginning b) Today

The vegetation is represented by *Pinus nigra* Arn, *Rubinia pseudoacacia* L, *Corylus avelana* L, *Evonymus europeus* L, *Prunus cerasifera* Ehrh, *Betula verrucosa* Ehrh and *Populus tremula* L. The self-accommodation of this vegetation has taken place mainly through spread of seeds from the tree species situated in the upper end of the embankment dump. One may find there also *Quercus petraea* Liebl, *Fraxinus ornus* L, *Ulmus campestris* L, *Juniperus communis* L and *Cornus mas* L.

The third site (Fig. 3) is the large quarry at the hydro-stadium. In order to stabilize the talus vegetation habitat in the quarry and to prevent further landslip 30-40 cm high horizontal fencing blocks have been installed at distance of 5 m from one another measured along the gradient. The thus formed small terraces have been afforested with 2-years-old *Pinus nigra* saplings planted at a distance of 2.00 m from one another along the row. The train-type part at the heel of the slope has been successfully stabilized by *Pinus nigra* Arn species, planted in 1970. Grass association has developed under the canopy.

In addition to *Quercus robur* L, *Viburnum lantana* L, *Ulmus campestris* L, *Carpinus betulus* L, other species have also accommodated themselves in the quarry in a natural way - *Rubinia pseudoacacia* L, *Betula pendula* Roth and the bushes *Cotinus coggigria* Scop, *Juniperus communis* L and *Clematis vitalba* L. Besides the herbal species mentioned in the other sites, spread here are also *Sangusorba minor* Scop and *Lolium perenne* L.

Fig.3. Third site a) After 20 years b) After 40 years



Thirteen sample areas were set up for the purposes of following the growth and development of the individual species and individual measurements were conducted at locations of different

Table 1. Biometrical characteristics of the species

Location of the simple area	Species	Parrticipaption	After 20 wears						After 40 wears					
			Growth in height (m)			Growth in diameter (cm)			Growth in height (m)			growth in diameter (cm)		
			average	max	min	average	max	min	average	max	min	average	max	min
Artificial made forest plantation														
Skeleton earth soil (slop20-25%)	Pinus nigra Arn	0,9	6,0	7,20	3,0	8,0	12,0	4,4	8,20	12,40	5,0	18,0	40,0	8,0
	Pinus silvestris L	0,8	3,80	6,0	3,0	6,0	11,6	3,2	8,60	11,50	7,80	17,4	20,8	12,5
Skeleton earth soil (slop 40 – 45%)	Pinus nigra Arn	0,9	4,80	-	2,80	5,0	-	2,5	7,80	10,20	5,30	9,3	17,8	8,5
Skeleton earth soil (slop 65-70%)	Pinus nigra Arn	0,8	3,70	7,0	1,20	4,0	8,8	1,2	7,20	8,0	3,40	6,8	13,5	5,6
Natural growth vegetation														
Platform site	Pinus nigra Arn	single	1,30	1,65	1,0	3,4	4,0	4,5	4,58	6,50	2,80	7,4	10,0	6,5
	Pinus silvestris L	single	2,40	-	-	4,0	-	-	5,60	8,70	3,50	8,2	9,5	5,8
Skeleton earth soil	Rubinia pseudoacacia L	single	4,20	6,20	4,0	6,0	8,8	3,4	8,30	12,50	6,50	10,5	12,5	8,0
	Betula pendula Roth	single	3,50	-	-	5,8	-	-	5,40	6,0	3,60	10,0	-	6,5
	Populus tremula L	single	7,0	-	-	5,7	-	-	8,50	-	-	6,8	-	-

gradients and substratum. The data presented in Table 1 refer to a period of respectively 20 and 40 years after the accommodation of the vegetation.

From the presented results it becomes evident that in the skeleton-substratum vegetation habitat (site No. 1) there exists great diversity in the growth of *Pinus nigra* Arn in height and in diameter because of the different conditions along the length of the waste bank during the entire period of survey. This affects the growth of the rest of the species as well. During the first period of 20 years *Pinus nigra* Arn showed reduction of the average height from 6.00 m to 4.80 and 3.70 m and of the average diameter respectively from 8.0 cm to 5.0 and 4.0 cm with the increase of the gradient. This result is connected to a great extent to the increase of the skeleton fraction and the density of the soil substratum with the increase of the gradient. During the second period of 20 years the growth of *Pinus nigra* Arn is also satisfactory. During that period the changes are respectively from 8.20m to 7.80 m and 7.20 m in height and from 16.0 cm to 9.3 cm and 6.8 cm. Generally speaking, with minor exceptions, they follow the pattern of the changes during the first period. During the period of 20 years *Pinus silvestris* L demonstrates somewhat lower indicators – average height 3.80 m, average diameter 6.0 cm. Under the same conditions *Rubinia pseudoacacia* L has two times lower indicators – average height 2.60 m and average diameter 2.0 cm. For the period of 40 years the picture is as follows: for *Pinus silvestris* L the results are respectively average height 3.80 m and average diameter 6.0 cm; for *Rubinia pseudoacacia* L – average height 4.30 m and average diameter 6.8 cm. Most probably the high aeration of the substratum is the reason for the insufficiently good indicators of the latter species.

The same trend has been studied for the forest inventory indicators: maximum and minimum height and maximum and minimum diameter for all the three species.

In the case of naturally accommodated vegetation (the second site) the measurements from the forest inventory show rich diversity of the data about the individual tree species for the different parts of the site. For instance, on the terrace the naturally accommodated 10-12 years old *Pinus nigra* Arn has average height of 1.30 m and average diameter of 3.4 cm. Twenty years later these parameters are respectively 4.50 m in height and 7.4 cm in diameter. Under the same conditions *Pinus silvestris* L has relatively good indicators – average height 2.40 m and average diameter 4.0. Twenty years later these indicators are as follows: average height 5.60 m and average diameter 8.2 cm. Adequate growth has been noted also for *Rubinia pseudoacacia* L, *Betula pendula* Roth and *Populus tremula* L in the train-type part of the waste bank (skeleton-earth vegetation habitat).

Relative measurement were performed also of the annual growth of *Pinus nigra* Arn under the conditions of skeleton-earth vegetation habitats under artificially planted species (Site No. 1) and under natural accommodation (Site No. 2). The data is shown in Table No. 2.

Table 2. Comparative measurements of the annual growth in height of Pinus nigra Arn in skeleton-earth vegetation habitat (cm)

Site	1967-1971	1972-1976	1977-1981	1982-1986	1987-1991	1992-1996	1997-2001	2001-2006
Site No. 1	63	129	185	104	86	94	159	820
Site No. 2	-	-	98	115	89	90	158	550

The data in the table shows on one hand the rich diversity in the values of the annual growth in height at both sites, and on the other hand the identical trend in the changes in the growth. Generally speaking, the data indicate that certain common features characterize the conditions of vegetation growth in the two sites. Both sites are aggravated by the very diverse (unequal) conditions in the different parts of the area. They possess, however, potential opportunities for accommodation of vegetation of ameliorative-rehabilitation designation.

On the basis of what has been said above we may make the following conclusions:

- Under the conditions of open cast mining (stone quarries) preconditions are created for formation of secondary vegetation habitats possessing specific peculiarities, which distinguish them significantly from the habitats on undistorted plots. On the grounds of the established similarity in the values on some parameters these habitats may be united in three major groups: rock-substratum, skeleton-substratum and earth-substratum habitats.
- On the studied skeleton-substratum habitats both the artificially planted species and the naturally accommodated vegetation demonstrate relatively good growth and good rehabilitation effect. The self-accommodation of vegetation provides grounds to reckon that at habitats of this type there exist the necessary minimum conditions for its growth and development.
- The aggravated conditions in the distorted terrains inhibit to a high extent the vegetation growth and development. Nevertheless, vegetation performs specific re-cultivation and rehabilitation functions.

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MELIORATION OF EXCAVATION SITE «SUVO RUDISTE» WITH AUTOCHTHONOUS PLANT MATERIAL

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Abstract: *The aim of establishing forest shelterbelt on the locality Milans peak (1976m,) the point on Kopaonik Mt. was to protect this site of strong winter winds that disturb ski cableway. This locality is a part of excavation site of old mine. There were used three year old spruce (Picea abies L. /Karst.) seedlings which were spontaneously produced from seeds on the sides of ski slopes at the locality «Duboka». This was the way to respect the principle of planting autochthonous plants in the national park. That was also the economic way to save several years for producing planting material with proper age and height and also adapted to the conditions of upper border of forest vegetation.*

The success of the seedling survival was 95 % in the first and 80% in the second vegetative season. The analysis of some morphometric properties (height, root collar diameter, number of new twigs, needle mass, etc.) as well as physiological vitality during first tree growing seasons, shows a very good trend of plant growth, development and quality.

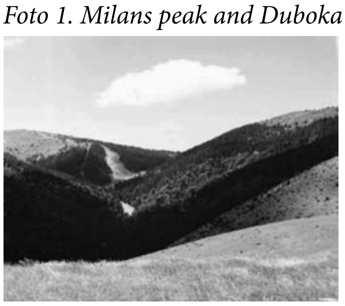
This positive experience of forestation with the method of transplanting autochthonous plant materials to the site with very extreme environmental conditions (temperature, wind, water), allows reclamation of wider areas in the future.

Key words: reclamation, excavation site, spruce, seedlings, afforestation.

1. INTRODUCTION

Milans peak (1976 m) is situated on the part of Kopaonik Mt. called Suvo rudište, where the mine magnetite was exploited for a long period of time and a depression of several hectares and 80 m deep was made. This part is not recultivated yet. As it is situated on the part of Kopaonik Mt. where picks of several ski funiculars are concentrated (Centar, Pančić, Duboka), there is a long time present problem of skiing obstruction by wind (Dožić S. et al., 2002.). The wind is here strong all over the year especially during the winter months. This was the reason here to try to find the way to reduce wind influence.

Foto 1. Milans peak and Duboka slope *Foto 2.The part of Suvo Rudište*



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2. NATURAL CONDITIONS

Milans peak on Kopaonik Mt. is lightly rotund shaped and is situated near the Pancic pick (2017 m). Now it is partly covered by sterile substrate with very poor grass vegetation and it is actually at the upper forest border. Several low spruce trees now indicate that there used to be a forest.

The data of the meteorological station on the Kopaonik Mt. are very good selected and calculated for the long period of time. Here are presented some of them for the higher altitudes (tab. 1).

Tab. 1. Average Month air temperatures and Precipitation For the Kopaonik station, (1971m), according Smailagić 1995.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	god.
Average Month temperatures.	-6,0	-5,2	-2,7	1,3	6,2	9,5	11,6	11,9	8,5	4,3	-1,0	-3,8	2,9
Average Month Precipitation	55,1	54,4	61,2	71,9	111,1	116,6	95,4	79,3	68,2	68,8	73,5	62,6	933,7

Air temperatures as shown in table 1. shows that the climate conditions on the Kopaonik Mt. top area are very severe (Alps) with the values of - 6,0 °C in January to + 11,9 °C in August. Maximal and minimal values are in the range from -30,0 °C to + 30,0 °C .

Those data shows that it is important to consider these values in selection of plant species for planting on the mountainous areas and severe conditions. If there is a strong and frequent wind it is quite clear that it is necessary to establish a wind shelter. If it is very often the wind velocity 20 m/sec, it is clear that the conditions for plant growth and development are very complicated.

3. MATERIAL AND METHOD

It was decided to use the plants from Kopaonik Mt. because it is well known that the provenance is the most important for plant survival. The plants were selected in the way to obtain the wind protection in a short period of time.

The three year old seedlings were diged and raised from the edge areas of ski slopes where they were developed from seed from surrounding spruce trees. Selected seedlings were of a very good quality, phenotype and physiological condition. They were transported to the place for planting, first they were putting in furrows and after that planted in pits 20x20 cm with addition of adequate substrate: pit soil, humus and organic nutrients. The total plot area was 750 m^2. The total number of planted seedlings was 132 and the planting space between plants was 1.5 x 1,5 m.

During the first vegetation season after planting it was done a watering of plants several times. Once it was done the soil digging around the plants.

The soil analysis was done by the standard methods.

During the two years the morphometrics measurements were done and statistical calculations also. The analysis of several physiological parameters was also done: needle mass, twig water potential by “pressure chamber” method, transpiration intensity by gravimetric method and also the analysis of biogenous macroelemenats content in needles. Nitrogen was identified by Kjeldahl method, phosphorous by colorimetric and potassium flame photometric method.

4. RESULTS AND DISCUSSION

The analysis of wind shelter belt establishing by using autochthonous spruce plants on the Milan's peak on the Kopaonik Mt. was done during 2003. and 2004. year. In the first growing season it was observed a very good plant survival for those conditions, 95 %, and in the second about 80%, but with some mechanical damages during the skiing season.

Some forest areas on the lower parts of the mountain show that it is possible for spruce forest to survive in such conditions and to protect from wind. The number of some other plant species is rather small and on the higher areas is more restricted, such are : *Vaccinium myrtillus*, *Minuartia recurva*, *Juniperus nana*, *Salix sp*. and other. There are also a very poor developed soil condition for plant growth and development including a bed watering during the growing season.

The soil analysis of experimental plot area shows the relative good granulometric content and alkaline reaction which is not the best for spruce species.

Tab. 2. Soil analysis from the site Suvo Rudište

Soil analysis from the site Suvo Rudište									
Soil Physical Properties									
Locality	Granulometric components %								
Kopaonik Pancic peak	2,0-0,2	0,2-0,06	0,06-0,02	0,02-0,006	0,006-0,002	>0,002	total		
							sand	clay+dust	
	1,03	12,47	23,10	25,00	11,10	27,30	36,6	63,40	
Soil chemical Properties									
Locality									
Kopaonik Pancic peak	pH		$CaCO_3$	Humus	C	N	C/N	Easy acceptable	
								P_2O_5	K_2O
	H_2O	HCl	%	%	%	%		mg/100g	
	8,30	7,13	1,25	3,27	1,90	0,22	8,60	40,00	44,00

Tab. 3. Results of seedlings growth and increment on the experimental plot

Number of planted seedlings	Average height of seedlings before planting	Average height of seedlings in the second year	Average root collar diameter	Increment in 2003.	Increment in 2004.	Total Increment	Number of dead seedlings
No.	cm	cm	cm	cm	cm	cm	No.
132	19,3	25,8	0,9	3,1	3,4	6,5	4

Tab. 4. Some physiological parameters of spruce seedlings in the wind break belt

year	Average dry mass of 100 needles	Twig Water potential May	Twig Water potential September	Transpiration intensity	Needle nitrogen content	Needle phosphorous content	Needle potassium content
	g	-bar	-bar	mg/g/min	%	%	%
2003.	1,6	1,5	1,9	0,8	1,2	0.8	1,7
2004.	2,2	1,6	1,8	0,6	1,5	1,0	1,9

The average height of seedlings two vegetation seasons after planting was 25,8 cm, total increment 6,5 cm, average root collar diameter 9 mm. This can be marked as a very good result of plant growth and development (tab. 3).

The analysis of water status parameters shows the very solid water potential values which means that plants were in a good water status without lack of water during vegetation season (May-September), transpiration intensity was not very high because of specific environmental conditions (altitude, wind etc.). The content of needle main macroelements (N,P,K) and the absence of chlorosis shows a good mineral nutrition of plants (Tab. 4).

Spruce has a demand for good amount ofpotassium and phosphorous and the demand for nitrogen is very large in the young stage of development. Spruce seedlings which grows on the higher pH values have a greater need for calcium and magnesium,especially on the soils with light mechanical content that are poor with these elements (Djukić, M. et al, 2004). That was the reason to put the supstrate with lower pH values with better content of mineral elements.

The very important factor for seedling growth and development is a good watering. For example, in the experiment with afforestation with spruce seedlings on the site „Rendara" on Kopaonik Mt., the spruce seedlings which were planted on the part of the locality with less water where lower and with less mineral elements in needles than those with better watering (Dožić, S. et al, 2002).

By using additional better quality substrate it was obtained the better plant survival and avoiding nutrition during vegetation. This was necessary because the soil on the locality where the windbreak belt was established, was with a very sterile soil with only few plants in rare density

If this kind of planting will be successful, it could be used as a model for reclamation a wider area of earlier excavation mine. This belt is planned to be broaden from 15 m to 50 m.

By this method it will be also achieved the lowest price for reclamation such sites.

It is also necessary to say that we need to follow the plant development during next years to be able to evaluate the suggested method.

Foto 3. Spruce seedling in the second season Foto 4. The experimental plot

5. CONCLUSIONS

On the basis of spruce seedlings morphological and physiological properties analysis it is possible to conclude that it would be possible to use seedlings from surrounding area for future afforesation or establishing wind break belts on Kopaonik Mt.

The growth parameters, average height of spruce seedlings two vegetation seasons after planting 25,8 cm, total increment 6,5 cm, average root collar diameter 9 mm shows a very good development.

The analysis of water status parameters shows the very solid water potential values which means that plants were in a good water status.

The content of needle main macroelements (N,P,K) shows a good mineral nutrition of plants.

This method is also a very suitable because it propagates the best provenance for seedlings, best quality and also the cheapest way.

It can be used on various localities with similar ecological conditions.

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DOUGLAS FIR (*PSEUDOTSUGA MENZIESII* (MIRB.) FRANCO) PLANTATIONS IN BULGARIA

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Abstract: *High productivity and relative resistance of Douglas fir made it one of the most broad used introduced coniferous tree species as in Europe so in Bulgaria. The introduction of Douglas fir in Bulgaria as tree species for afforestation purposes started in the beginning of the last century and up to day the area occupied by Douglas fir plantations reach 6 714 hectares.*

The area and growing stock distribution of Douglas fir plantations according to the State Forestries and Regional Forestry Boards in Bulgaria were analyzed. Based on it and on the productivity reached in some of the oldest plantations, an attempt for assessment of perspectives for breeding Douglas fir in Bulgaria was carried out.

Taking into consideration the productivity, growth capacity and general status, Douglas fir plantations can be considered as successful and the species as perspective for more broad breeding mainly for intensive plantations.

Key words: Douglas fir, tree breeding, afforestation,

1. INTRODUCTION

Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) is one of the most valuable tree species not only in the western part of North America, where its natural distribution area is, but worldwide. Thir ty five years after the discovery of this species by A. Menzis in 1792, it was introduced on British Isles. Since then, Douglas fir was introduced in almost all European countries, New Zealand, Australia and some temperate regions of South Africa and Argentina.

Big number of species was introduced in Bulgaria from North America but none of them acquired such economic importance as Douglas fir. Just after its introduction in the beginning of XX century the first industrial plantations of this species were established and since then their areas continuously increased.

The aim of the present paper is, analyzing the distribution and the productivity reached up in some plantations, to outline the perspectives for Douglas fir breeding in Bulgaria.

2. OBLECTS AND METHODS

Objects of investigation are plantations of Douglas fir and their distribution in Bulgaria, the data about their productivity being determined as on the base of our measurements in the oldest plantations near Rila Monastery, Koprivshtisa and Kazanlak, so by using statistical data.

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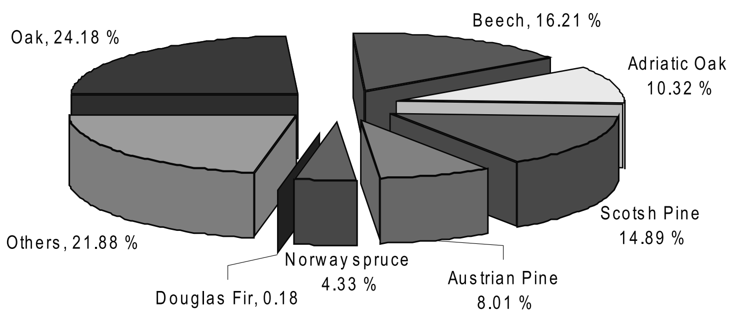
3. RESULTS AND DISCUSSION

The existing paleo-botanical data show that the breeding of genus Pseudopsuga in Europe is not innovation but reintroduction of the genus in areas, which it inhabited before. Hermann and Ching (1973) and Hermann (1981) reported number of paleo-botanical finds in France, Poland and Upper Italy, which prove that Pseudotsuga existed in Europe about 750 000 years ago. In Bulgaria Stefanov and Yordanov (1935) found seeds and needles of Pseudostuga representatives in Pliocene sediments near Kurilo Village – Sofia District. The same year new finds were discovered in the sediments near Podgumer Village which contain not only seeds and needles but also cone scales. This proves the presence of Pseudotsuga genus in Sofia Plain in the early Pliocene. The authors emphasized that its participation in the composition of the local vegetation had been insignificant and had not influenced the ecosystems' development. According many researchers one of the most probable reasons for the disappearance of Pseudotsuga representatives from Europe is the fact that the main mountain chains here are oriented in east-west direction, in contrast to North America and South-Eastern Asia, which was obstacle for the migration of species from North and Central Europe during the glaciation. This caused in lesser number of tree species and lower biodiversity in Europe in comparison with North America and South-Eastern Asia, where the main mountain chains are directed north-south and the climate changes were related with migration and evolutionary processes, not with species disappearance.

The introduction of Douglas fir in Bulgaria, or the reintroduction of the species in the sense of above presented historical review, started in the beginning of XX century with its' planting in some parks and gardens in the country. Right after that, in 1906-1908, the first plantations above Knyajevo and Shipka towns were established. Since then the area of the created plantations constantly increased up to 1989-1990. After that there was decrease in the afforestation activities mainly due to lack of finances and tendency to give priority to the natural regeneration.

In the report about distribution of afforested area according to tree species fir in Bulgaria Douglas occupies 6 714 ha, which presents 0.62 % of the conifer forests (Figure 1). The age structure of Douglas fir stands includes the range of I to V age classes, the most widely distributed being the plantations of II (21-40 years) age class - 4812 ha. The period when most of these plantations were established coincides with the period of most active afforestation in the country. The oldest plantation was created in 1908 in the Shipka part of Balkan Mountain, in the place "Dimovets". Our measurements show that maximum height of the trees is 51 m and maximum diameter – 1.02 cm.

Figure 1. Participation of the main tree specias in Bulgarian forest



Douglas fir plantations were established on the territory of all Regional Forestry Boards (RFB), in 85 State Forestries (SF) and Game Breeding Stations (GBS), but their distribution is very unequal (Figure 2). Afforestation was performed in all three forest vegetation zones in

Bulgaria: Mizia, Thracia and South Near-Boarder zone, in the altitudinal range from 50-60 m on the eastern slopes of Balkan Mt. (Haramiiski dol, Varna State Forestry) up to 1400 m (Rilski Manastir State Forestry). In north-eastern regions of the country (Ruse, Shumen and Varna Regional Forestry Boards) the area planted with this species is insignificant, which is logical having in mind that the sum of precipitations here is minimal. The biggest in area are the plantations in Smolyan RFB - totally 1915 ha, Kyustandil RFB – 1020 ha, Stara Zagora RFB -653 ha and Lovech - 612 ha. According to State Forestries the biggest is the area of Douglas fir plantations in the Rhodope Mt: Zlatograd SF - 738 ha and Smilyan SF - 689 ha, followed by Troyan, Nevestino and Tsaparevo State Forestries.

The practice of establishing conifer mono-plantations was criticized since a long time, as in Bulgaria so abroad, because of their decreased resistibility and reduced biodiversity. As a matter of fact Douglas fir grows very successfully with many indigenous conifer species as Scots pine (*Pinus silvestris* L.), Norway spruce (*Picea abies* (Karst.) L.), silver fir (*Abies alba* Mill.) and with some broadleaves – beech (*Fagus sylvatica* L.), durmast (*Quercus sessiliflora* Salisb.), birch (*Betula pendula* Roth.), hornbeam (*Carpinus betulus* L.), which makes the species totally responding to the local landscape. We should emphasize that according to the two expert assessments about withering of conifer plantations and analysis about Douglas fir withering as result of dry period in 1990s (Donov et al., 1991; Popov,

Hristov, 1998) the percentage of withering for Douglas fir was no higher than the average value established for the plantations of Scots and Austrian pines.

The total growing stock of Douglas fir for the country is 2 161 977 m^3. According to Regional Forestry Boards the biggest is the growing stock on the territory of Sliven, Smolyan and Blagoevgrad RFB and according to State Forestries the leading position have Sliven SF - 200 890 m^3, Zlatograd SF - 113 100 m^3 and Tsaparevo - 84 105 m^3. In table 1 the reached up growing stock and mean annual increment in some of the measured plantations are presented.

Table 1. Growth indexes in some PSP (Permanent Sample Plots) in Bulgaria

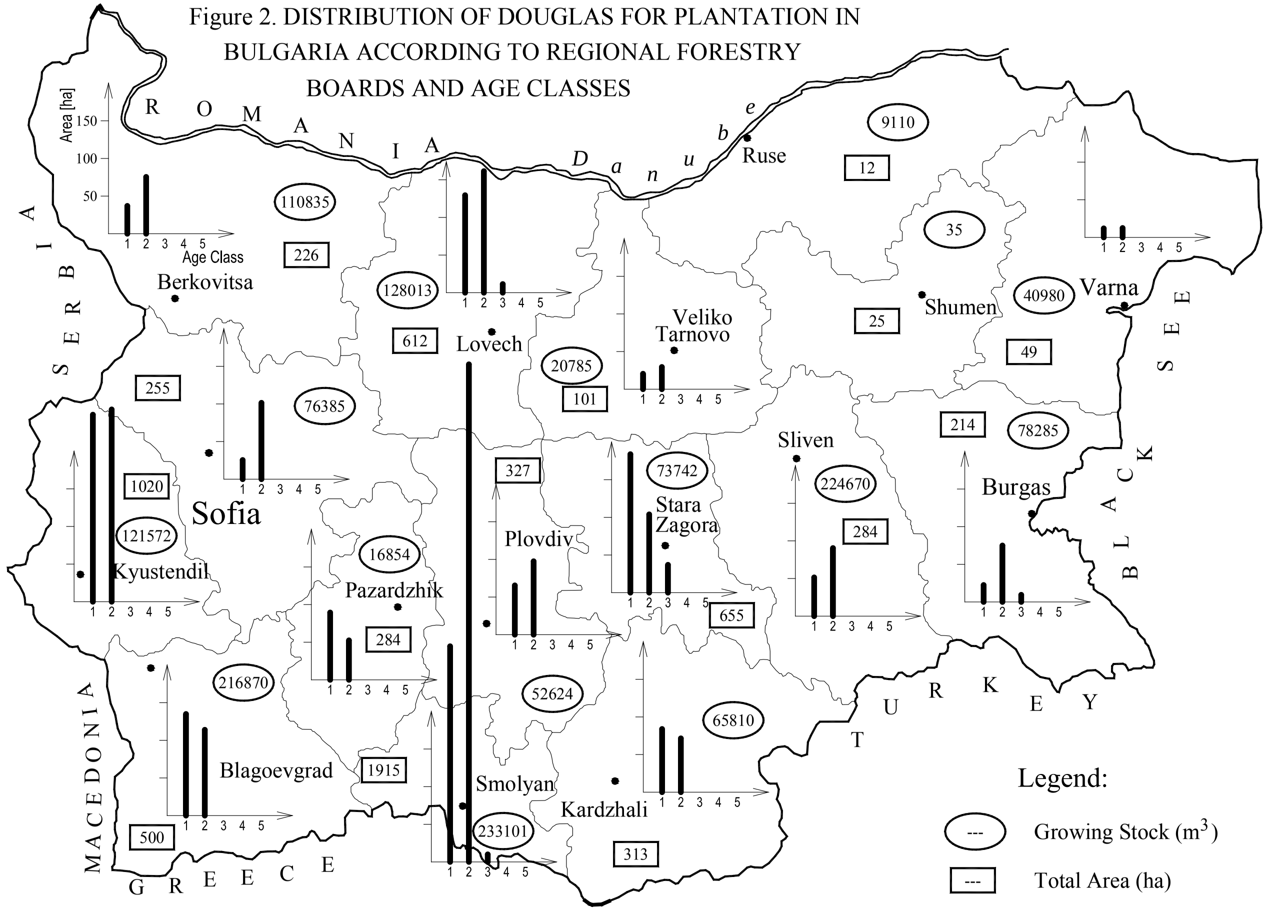
Number of PSP	State forestry	Age (years)	Height (m)	Bonitat	Growing stock (m^3 ha^{-1})	Mean annual increment (m^3 ha^{-1})
1	Smiljan	41	28,5	1	636,2	15,5
2	Smiljan	35	20,6	1	543,6	15,5
3	Zlatograd	35	25,6	1	512,3	14,8
4	Zlatograd	37	27,2	1	441,2	11,9
5	Koprivshtitsa	71	33,0	2	1232,7	17,4

Comparing this productiveness with Bergels' growth tables (Bergel, 1985) it was defined that Permanent Sample Plots (PSP) 1-4 are of I bonitat and PSP No 5 corresponds to II bonitat. That productivity could be increased by using of breaded reproductive materials and précising the forest management practices, i.e. performing of timely and more or less intensive thinning.

Bulgaria is one of the European countries where the area of productive forests decreases in favor of increased number of protected territories – reserves, national and nature parks. Their area towards 1991 was 2.4% of the total country's area. Recently they present about 5% and in the National Strategy for conservation of biodiversity (1993) it is foreseen the areas with different status of protection to reach up 10% of the country's territory.

Having in mind this progressive decrease of industrial forests the problem to increase the productivity becomes of prior importance. In countries where private forests prevail, the pro-

Figure 2. DISTRIBUTION OF DOUGLAS FOR PLANTATION IN BULGARIA ACCORDING TO REGIONAL FORESTRY BOARDS AND AGE CLASSES



cesses of intensification take place first and with priority in them. In Bulgaria the percentage of private forests is 16.3% and for the moment just in part of them real forest management activity is performed.

The main role of Douglas fir plantations, in this respect, is to ensure bigger timber production per area unit, which will help to reduce the pressure on natural forests. In long term aspect this will help to increase the area of protected territories without decreasing the quantities of yielded timber, as it will be naive to expect that the low levels of timber utilization in the last years of economic transition will be preserved in the future.

On the first place Douglas fir in Bulgaria should be used for the creation of intensive plantations, as its participation can reach up to 2-2.5% of the conifer forests area. It is recommendable certain small number of the old plantations as those in Kazanlak SF, Rilski Manastir SF and Koprivshtitsa SF to be managed at comparatively long rotation period of 200-250 years. The profits for the society will be from one side establishment of old forests from an "exotic" species and from other side this will ensure source of valuable timber. We should also emphasize that Douglas fir plantations can completely respond to the requirements for additional forest profits (non-wood products, recreation, etc.)

It is necessary to determine the maximum possible areas for Douglas fir breeding using also the abandoned agricultural lands for establishment of intensive plantations. As the forest policy is not limited in the frames of the forest administration but is also element of the social sphere, the specific activities for its implementation should be elaborated by experts, with consideration of the contemporary scientific and applied knowledge.

4. CONCLUSION

The combination of high productivity and good wood quality makes Douglas fir very suitable for establishment of intensive plantations for timber production. This species is sustainable to the local conditions, conformable to landscape and the plantations, except wood yielding, ensure the specific additional forest profits, typical for the natural stands.

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AUSTRIAN PINE (*PINUS NIGRA* ARN.) PLANTATIONS ESTABLISHED ON BARE KARST TERRAINS IN THE REGION OF BELOVO

Emil POPOV[1]

Abstract: *The experiment includes two Austrian pine (Pinus nigra Arn.) plantations at same age class situated on north and south facing slopes, affected by strong anthropogenic influence, at region next to Momina Klisura village – Belovo State Forestry.*

The results from reforestation of completely devastated terrains situated on marble mother rock, on the base of species productivity and growth capacity were evaluate.

The growing stock in PSP 1 and 2 reaches up to 380.6 m^3 at age of 42 and 190.98 m^3 at age of 47 years respectively.

The biometric indexes of Austrian pine characterizing growth – mean diameter, basal area and growing stock in PSP 1 proved to exceed those for the corresponding bonitat class, which clearly demonstrate the influence of aspect and inclination on the site conditions and growth indexes.

Taking into consideration the productivity, growth capacity and general status, the studied Austrian pine plantations created on devastated karst terrains can be considered as successful.

Key words: reforestation, devastated karst terrains, Austrian pine, mean annual increment

1. INTRODUCTION

The Austrian pine (*Pinus nigra* Arn.) forests in Bulgaria occupy 292 267 ha (Forest Fund 2, 2005). This is one of the main species used for afforestation and due to its specific ecological and physiological peculiarities it is extremely valuable for establishment of anti-erosive plantations on karst terrains. Recently, as part of the plantations reaches their reproductive maturity, there is increased scientific interest towards them in relation with clarifying of some problems concerning the regeneration and transformation processes in these plantations (Zlatanov, Hinkov, 2004; Zlatanov, Hinkov, 2005).

Regarding the expected climate changes and the corresponding significant changes of vegetation cover in global scale, assessment on the status of Austrian pine plantations created in extreme conditions was accomplished. Under extreme conditions we will consider such temperature, humid and edaphic environment that put the species on its eco-physiological limits of existance.

Number of forest tree species is known to be highly variable not only according to economically valuable traits as growth in height and diameter but also due to some characteristics related to their resistance towards unfavorable environmental conditions. In Bulgaria, the adaptation of forest vegetation to climate changes is particularly important in the lower part of the country, up to 800 m altitude. Many forest tree and shrub species as oriental hornbeam (*Carpinus orientalis* Mill.), hawthorn (*Crataegus monogyna* Jacq.), lilac (*Syringa vulgaris* L.), thorny bush (*Paliurus aculeatus* Lam.), pubescent oak (*Quercus pubescens* Willd.), Hungarian oak (*Quercus frainetto* Ten.), Adriatic oak (*Quercus cerris* L.), field maple (*Acer campestre* L.), Siberian elm (*Ulmus*

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pumila L.), European hackberry (*Celtis australis* L.), etc., show good viability and growth on karst terrains at different rates of unproductiveness.

The Austrian pine (*Pinus nigra* Arn.) also grows on these terrains forming comparatively sustainable stands with productive indexes characteristic for the low bonitat classes. As typical calciphyte and being indigenous species Austrian pine had been preferred in afforestations on rendzinas soils and karst terrains as in the low-and-middle mountain zones, so in the low plain-hilly and hilly - fore-mountain belt of the oak forests (0-500 m).

The scientific investigations on the condition and productivity of Austrian pine plantations created on karst terrains are limited. The aim of the present paper is to give an assessment on the growing stock and status of Austrian pine plantations, established on terrains at different rates of degradation.

2. OBJECTS AND METHODS

Object of investigation are two Austrian pine plantations situated in the Low plain-hilly belt of deciduous oak and xerothermic forests, Thracian forest vegetation zone, Belovo State Forestry, in the vicinity of Momina klisura village. The plantations were created in rectangular schemes of 0.75 x 0.5 m and initial density of 26 666 seedlings per ha. In the plantation containing the second permanent sample plot (PSP 2) thinning with intensity of 15% were carried out. Table 1 presents general data about the situation and the sites on which the two PSP are established.

Table 1. Site characteristics of Permanent Sample Plots (PSP)

PSP, compartment	Altitude (m)	Aspect	Slope (degrees)	Soil type	Main rock	Site type
PSP1 396 n	400	NE	18	Rendzinas	marble	Dry, on rendzinas 122 T–I AB1
PSP2 396 l	400	S	25	Rendzinas	marble	

The distribution area of Austrian pine in Bulgaria is based on data from National Forestry Board (Forest Fund – 2, 2005). For determination of the soil and site types Soil map in scale 1:400 000 (Koinov, 1968), Instruction for defining and mapping of forest site types and data from the Forest inventory plan were used. The methods of preliminary terrain research and establishing of sample plots were applied. For determination of the diameter, height and growing stock standard inventory methods were used – the diameters were measured at breast height of 1.3 m with 1 cm accuracy and the heights with precision of 0.25 m. The growing stock was determined according to the volume tables-measurement method (Iliev et al., 1980). For defining the plantations bonitats, bonitat table for Austrian pine plantations was used (Tsakov, 2004). The height classes were determined through height-class tables for Austrian pine (Nedyalkov et al., 2004 a) and the volumes - through volume tables for Austrian pine with bark (Nedyalkov et al., 2004 b).

The assessment of the general health status of the plantations was performed on the base of observation of all trees in the sample plots to establish rates of withering, as well as the trees started to form umbrella-like crowns.

3. RESULTS AND DISCUSSION

As big parts of the Belovo State Forestry territory are typical example for entirely devastated due to anthropogenic influence forest areas, which were afterwards object of mass-scale afforestation aiming restoration of forests, we will present the results and discussion starting with some chronological data about these activities.

At the end of IXX century construction of railway line connecting Istanbul with Europe through Plovdiv, Sofia and Belgrade was in process. Part of the agreement for this construction was the 36 years concession for exploitation of the forests around Belovo town. To define this as "over-exploitation" will be not enough – 10000 ha mainly of oak forests were completely cut down, after that free pasture of big goat flocks was allowed on the deforested areas. This, combined with the fact that the main rock in the region is marble and the prevailing inclinations of the terrain are in the range of 20°-35°(40°), led to quick and total liquidation of the forest vegetation, intensive erosion processes and denudation of the main rock.

Afforestation on all terrains with active erosion processes started in the beginning of 1950s in the region of Belovo and its neighboring State Forestries, the work being accomplished at the end of 1980s. The afforestation technology was planting of Austrian pine seedlings in holes. This campaign was called by many forest managers "battle for reforestation and landscaping" as:

"The soil required for covering of the roots was transported in boxes, pails and sacks. In places, where holes could not be open with pickaxes the rocks were detonated. Years after initial afforestation the withered saplings were replaced by new ones. In summer times the seedlings were protected from sun radiation by shading with stones and even irrigated." (Panov, 2000). Exactly these were the conditions and planting techniques at which south facing plantation was created.

The investigated plantations are at similar macro-climatic conditions. There are no differences also regarding the altitudes. The two plantations are of III (41-60 years) age class. The soils in both sample plots are rendzinas, sandy-loamy, crumbly and rocky, but in PSP 1 the soil profile is deeper, with well developed forest litter, while in PSP 2 the soil is very rocky, at some places the main rock still appearing on the surface. The area under PSP 2 had been eroded in greater extent when the plantations were created and at the moment of its establishment soil formation process was slowly progressing. The exposures differ significantly – northeastern (with inclination of 18°) for PSP 1 and southern (with inclination of 25°) for PSP 2. This considerably influences the temperature and moisture regime in the two sample plots.

The plantations where the sample plots are established are 42 and 47 years old with canopy density of 1.0 and 0.8 respectively (Table 2).

Table 2. Growth characteristics of investigated plantations

Sample plots	Number of trees per hectare	Age (years)	Canopy closure	Average diameter (cm)	Average height (m)	Bonitat	Basal area (m2 ha-1)	Growing stock (m3 ha-1)	Average volume increment (m3 ha-1)
PSP 1	3587	42	1	13,8	13,8	3	53,95	380,6	9,06
PSP 2	2964	47	08	11,7	10,50	4	31,40	190,98	4,06

The average diameters established for PSP 1 and PSP 2 are 13.8 cm and 11.7 cm and the average heights are respectively 13.8 m and 10.5 m. taking into consideration the values for average height of the investigated plantations and according to the Growth and production tables for Austrian pine plantations in Bulgaria (Tsakov, 2004), their bonitat was determined as IV. It should be mentioned, however, the significant difference in initial density of the analyzed plantations in comparison with those on the base of which the Growth tables were created (as it was already pointed out the initial density of examined plantations was 26 666 saplings/ha, while the Growth tables were based on 9 250 seedlings/ha at age of 10 years for IV bonitat). The values for basal area and growing stock are close to the table values only for PSP 2, where thinning was performed. In order to precise the estimation of Austrian pine growth in the investigated plantations the values for average height, the basal area and the growing stock per hectare were compared with the corresponding values for this species in the Experimental tables for Austrian pine plantations on limestone terrains of 8 to 14 bonitat classes and in the Experimental tables for Austrian pine plantations on non-carbonate soils of 8 to 18 bonitat classes (Duhovnikov, Iliev, 1977). Absolute bonitat system is used in these tables – the average height at age of 50 years. The plantation on the southern, more degraded site is of 12th bonitat according to the tables for Austrian pine plantations on limestone terrains, while the other one – on northeastern exposure is of 16th bonitat, the values for basal area and growing stock exceeding those in the table with respectively 32% and 31%. These results show that the investigated plantations have good productivity in these site types conditions and besides their anti-erosive and landscaping effect, they could be also used as source of small and middle sized timber.

In 1980s Expert assessments on the health status of forest plantations and some forest stands (Donov et al, 1991) and Expert assessments on the health status of Scots and Austrian pine plantations in Bulgaria (Donov et al., 1994) were performed in relation with aggravation and withering of more than 25 000 ha of conifer plantations. According to the materials of these expertizes there was no withering recorded for the plantations in Belovo.

According to the observations performed in order to establish withering trees and trees starting to form umbrella-like crowns just in PSP 1 solitary dying trees were found, but the fact that all of them are suppressed, under the main canopy or with broken tops suggests more probably process of natural thinning than health problems in the whole plantation. No trees with umbrella-like crowns were established.

4. CONCLUSION

The obtained results show relatively good productivity of the Austrian pine plantations of III age class. The average increment in volume for the plantations on north facing and less degraded site is 9.06 m^3ha^{-1} and for the plantation on south facing and strongly degraded site – 4.06 m^3ha^{-1}. The growing stocks at ages of 42 and 47 years for the two sample plots are respectively 380.6 m^3 and 190.98 m^3. Having in mind the established general status, productivity and growth abilities of Austrian pine on the concrete sites we can consider the afforestations with this species on strongly devastated by anthropogenic influence terrain as successful not only from anti-erosion and landscape point of view but also as possibility for timber yielding.

Based on these results further investigations aiming expanded analysis of the status and productivity of Austrian pine plantations established on karst terrains should be performed.

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POSSIBILITY OF APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) IN THE CONDITIONS OF THE EXPERIMENTAL STATION SNAGOVO

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Abstract: *The Universal Soil Loss Equation is the most famous method for the estimation of soil loss applied worldwide. It is named Universal, because it can be applied to other regions outside the USA, if its parameters are adapted to local conditions. The results obtained by the experimental, field research of water erosion on sample plots at the experimental station Snagovo were studied aiming at the possibility of application of this equation for the calculation of soil loss in the research conditions. The calculation of soil loss by USLE was performed by the method which has so far been applied in our practice. By the comparison of the results of soil loss calculation by the Universal Soil Loss Equation (USLE) and the measurement on sample plots, it was concluded that the values of soil loss calculated by the USLE differ from the values obtained by sample plot measurements.*

Key words: erosion intensity, sample plots, soil loss, USLE.

1. INTRODUCTION

The Universal Soil Loss Equation - USLE is by all means the most famous and the most widely applied method for the calculation of soil loss. It is the mathematical model which is used for the estimation (prediction) of the average annual soil loss. It is named "universal" because, although it was conceived and developed in USA, if the geographical and climate limitations are eliminated, it can also be applied throughout the world, outside USA.

The aim of this study was to examine the possibility of implementation of the Universal Soil Loss Equation (USLE) in the conditions of the experimental station Snagovo. The soil loss results obtained by the USLE calculation were compared to the results obtained by direct measurements on the sample plots of the experimental station Snagovo.

2. METHOD

The research developed in two directions: direct field measurement of sediment yield on erosion plots and the comparison of these results with the results obtained by the calculation by USLE method.

All the elementary data applied in this study are the results of the measurements and monitoring performed in the experimental station Snagovo during the period 1973 - 1990.

The meteorological measurements and monitoring were performed at the weather station established within the framework of the experimental station, in the vicinity of sample plots.

The events of soil loss were observed and recorded on sample plots which were rectangular in form, length 20.0 m and width 2.5 m. Runoff water and sediment were collected at the

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bottom of each plot bordered with sheet-aluminium strips in concrete-lined basins, volume cca 1000 l.

The soil loss data, i.e. the quantity of sediment inflow, were measured by the method of representative sample taken from the total inflow quantity of water and sediment. In this way, the total quantity of sediment was measured for each rain which caused soil loss, and the measured data were presented in t km^{-2}.

The calculation of soil loss by the Universal Soil Loss Equation (USLE) was based on the general equation of soil loss:

A = R x K x L x S x C x P

by the method which has so far been applied in our practice, i.e. with the values of input parameters adopted as follows:

- Value of rain erosivity factor R was obtained by the analysis of pluviographic records;
- Value of soil erodibility factor K was calculated based on the equation by Wischmaer, Johnson and Cross;
- Value of slope length and slope steepness, factors LS, were calculated based on the equation which is based on the theory of the unit rate of flow;
- Values of plant cover and crop management, factor C, were adopted based on the published tables;
- Values of erosion control measures and works, factor P, were adopted according to the Tables by Wischmaer and Smith.

3. RESULTS

3.1. Characteristics of the Experimental Station

Experimental Station Snagovo was established in 1973. It is situated west of Zvornik in the headwater part of the river Spreča in the hamlet Jeremić near the village Snagovo.

The sample plots range within the altitudinal belt from 540 to 580 metres. Parent rock consists of massive and layered limestones. Brown soil was formed on compact limestones.

Based on the monitoring and the measurement data of precipitation and temperatures, during the study period mean annual precipitation sum amounted to 977 mm, and mean annual air temperature was 9.7 ^{0}C. The coldest month in the year was January with mean monthly temperature –0.3 ^{0}C, and the warmest month was July with mean monthly temperature 19.0 ^{0}C. During the study period, annual maximum precipitation was recorded in 1981 and it was 1145 mm, whereas the driest year was 1990, with annual precipitation 664 mm.

Table 1. Basic characteristics of sample plots

Plot number	Slope %	Exposure	Land use	Area (m2)	
				per slope	reduced
6	43.48	S	bare land	50.0	45.85
8	43.48	S	farmland	50.0	45.85
10	43.48	S	meadow	50.0	45.85
16	26.95	S	bare land	50.0	48.30
19	26.95	S	farmland	50.0	48.30
21	26.95	S	meadow	50.0	48.30
27	17.33	S	bare land	50.0	49.25
30	17.33	S	farmland	50.0	49.25
32	17.33	S	meadow	50.0	49.25

The soil loss presented in this study was monitored and measured on 9 sample plots, under different plant covers and distributed on different slopes. The basic characteristics are presented in Table 1.

The plots under meadows represent the areas which have vegetation cover throughout the year; farmlands are one period of the year without vegetation cover and without full coverage, while bare lands represent the areas which are without any vegetation cover throughout the year.

3.2. Results of Measurements and the Analysis of Results

The value of measured average annual soil losses from unit area ranged from 0.06 t km^{-2} on sample plot no. 32 (meadows on the slope 17.33 %), to 3231.91 t km^{-2} on sample plot no. 6 (bare land on the slope 43.48 %).

The calculation of soil loss by Universal Equation was performed by the method which is applied in our practice, i.e. based on the equations for other "similar" areas, because the data for the study are not available. The calculation was done for each experimental plot, and the calculated values represent the mean annual soil loss from the study areas.

The values of individual parameters and the calculated soil loss by USLE method, as well as the soil loss values obtained by measurement of all study plots, are presented in Table 2.

Table 2. Calculated and measured values of soil loss

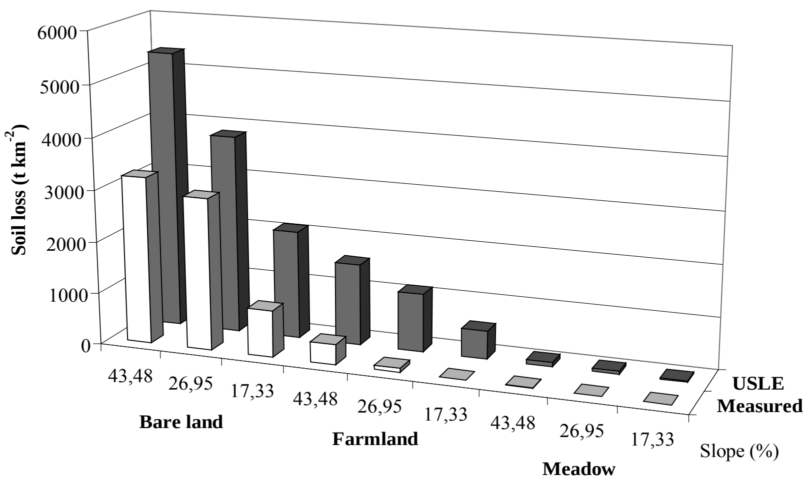
Plot number	R MJ cm ha-1 h-1	K t ha MJ-1 h ha-1 mm-1	LS	C	P	A t km-2	Measured data t km-2
6	119.98	0.24	7.44	0.190	1.0	5361.00	3231.91
8	119.98	0.24	7.44	0.062	0.9	1574.40	389.06
10	119.98	0.24	7.44	0.003	1.0	84.65	6.65
16	119.98	0.32	3.99	0.190	1.0	3833.40	2944.27
19	119.98	0.32	3.99	0.062	0.9	1125.80	77.63
21	119.98	0.32	3.99	0.003	1.0	60.53	0.33
27	119.98	0.31	2.25	0.190	1.0	2094.10	903.87
30	119.98	0.31	2.25	0.062	0.8	546.68	4.94
32	119.98	0.31	2.25	0.003	0.8	26.45	0.06

The heterogeneous results, i.e. great deviations in the values of annual soil loss per individual plots, can partly be explained by the complexity of erosion process, i.e. sediment yield as the consequence of the collective impacts of numerous factors. The impact of numerous factors of erosion does not exclude the possibility that in certain cases, some of the factors had a more significant effect on erosion intensity, i.e. sediment yield.

The comparison of the soil loss values calculated by USLE method and soil loss data from sample plot measurements shows that the values of soil loss obtained by the implementation of USLEare mainly multiply higher.

Universal Soil Loss Equation is a mathematical model in which the mathematical symbols and relations reflect the laws and correlations between the observed phenomena in nature. Such models represent a simplified vision of the natural processes and relations, so regardless of their complexity, they are still unable to represent the complete idea, and there always remains a smaller or a greater part of the process which could not be reproduced and explained by the model.

Diagram 1. Measured and calculated values of annual soil loss



The above facts can only partly explain the deviations of the measured values soil loss of the values obtained by the calculation by USLE. By all means the basic reason of the deviations is the fact that the factors are not adapted to our conditions. Namely, the Equation has six basic factors which are expressed numerically. Their numerical determination was based on the long-term research on the territory of the USA. However, the basic parameters of erosion (climate, relief, soil,...) in our study area differ from those in USA. By all means, the calculation results would be more approximate to the measured data if the calculated factors were adapted to our conditions.

4. CONCLUSION

The heterogeneous results of the measured data confirm the generally known facts on the complexity of erosion process and sediment yield, as well as the impacts of numerous local factors of erosion.

By the comparison of soil loss data obtained by USLE method and soil loss data obtained by field plot measurement, it can be concluded that the compared values differ. By all means, the main reason for the deviation is that the parameters are not adapted to our conditions. USLE equation is the most widely accepted method for the calculation of soil loss, however, in principle, the methods for sediment yield calculation, regardless of their high complexity, cannot be uncritically implemented in all regions, primarily because of the complexity of the process and the impacts of numerous, often local factors. This means that, in the implementation of the Universal Soil Loss Equation methodology, it is necessary to adapt its individual parameters to the local conditions.

This can be achieved only by the large-scale research, by the construction of basic and standard plots according to USLE methodology, at different locations throughout the study region. It is understandable that the research period and the period of measurements should be as long as possible, but it is better to have a short series of measurements, than to calculate based on the parameters for different regions.

Only in this case, after the definition of the equation parameters, the implementation of the Universal Soil Loss Equation for the calculation of erosion intensity on the study area, would be correct.

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SIGNIFICANCE OF SUSTAINABLE UTILISATION OF MEDICINAL HERBS ON MT. STARA PLANINA

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Abstract: *In the economy of many countries, the utilization of medicinal herbs is a significant branch. Thanks to the evident biodiversity and favourable natural conditions in Serbia, there are many places rich in medicinal plants. One of the most representative places in this respect is Mt. Stara Planina. The two plots in the Visočica basin, where the possibilities of sustainable utilization of medicinal herbs were investigated, are: Široke Luke and Prelesje. Time norms were established by the method of chronometry, in order to establish the real price. The measurements for the study of technological processes were also performed. The worker was well trained to use this method and to fill in the prepared form, knowing the details of the technological process. By the method of Prof. Gavrilovic, we assessed the state of erosion before and after medicinal herb harvesting. In this respect, we emphasised the significance of regular harvesting of medicinal herbs on the steep slopes which are potentially endangered by erosion. In this way, several effects are achieved: (1) protected soil, as one of the most important natural resources; (2) protected biodiversity; (3) long-term economic efficiency.*

Key words: natural conditions, medicinal herbs, time norms, soil erosion, protection, economic efficiency.

1. INTRODUCTION

The hilly and mountainous areas in Serbia are distinguished by high floristic and vegetation diversity. The area of Stara Planina, with the localities in the basin of the river Visočica was selected for the research of the sustainable harvesting of medicinal plants. The headwater part of the river Visočica basin is on the territory of Bulgaria, and it flows through Serbia through the district Visok, covering also the parts of the municipalities Dimitrovgrad and Pirot. The most significant tributaries of the Visočica are: Dojkinačka Reka with its left tributary Jelovička Reka, Rosomačka Reka, Kamenička Reka and Krivodolska Reka.

The river Visočica basin belongs to the area of Balkan Serbia with the continental climate. Mean annual precipitation is from 717.3 mm (data at the raingage station V. Lukanja) to 917.2 mm (data at the raingage station Dojkinci). Mean annual air temperature is 9.5°C. Parent rock in the Visočica basin consists of the rocks of Mesozoic age. They are mainly poorly resistant sandstones, slates, marls and conglomerates. Limestones prevail in the fringe parts and along the entire left side of the river basin, i.e. layered grey limestones with siltstones. The geological formations of the rocks are almost regularly intermixed, so they often form flysch. As for soil types, based on the genetic-evolution base, in the wider area of sample plots there are two series: soils on red sandstones and soils on limestone-dolomite. The characteristic of these soils is that they are shallow, sandy, skeletoid, mainly acid and relatively poor in humus, which are mainly the characteristics of mountain soil types. In this area, the following types of soils are distinguished: eutric cambisols (eroded), mountain black soils (rendzinas and rankers), brown soils on limestone, acid brown soils, as well as alluvial soils of different degrees of development.

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Figure 1. Sample plot 1 in the area of Široke Luke in the Jeloviška Reka basin

The areas in which the collection of medicinal plants was measured are situated at two locations in the Visočica basin: Široke Luke and Prelesje. In the area of Široke Luke, which is in the Jeloviška Reka basin, two sample plots were selected in the watershed between the Jeloviška Reka and Mala Reka (right tributary of Jeloviška Reka). The areas are at the altitude of about 900 m. Two sample plots were also selected in the area of Prelesje, in the Dojkinačka Reka basin, at the altitude of about 1100-1200m.

2. METHODS

The assessment of the intensity of erosion processes before and after the collection of medicinal plants on the sample plots was based on Professor Gavrilović's method (Gavrilović, S. 1972).

The norms of medicinal plant collection times, in the aim of the objective price setting, were determined by the method of chronometer measurement.

3. RESULTS

3.1. Intensity of erosion processes

Natural characteristics of the Visočica basin affect the occurrence of erosion processes of different intensities. In individual parts of the basin, such as the right slopes in the vicinity of the village Rsovci, there are erosion processes of the first category of erosion hazard after Gavrilović. The prevailing processes in the basin are medium and weak erosion. In the entire river basin, it can be concluded that the prevailing process is that of medium erosion, i.e. its lower limit, with the erosion coefficient Z_{sr}=0.41.

Table 1. Erosion intensity on sample plots before and after medicinal plant collection

Sample plots	Erosion state (erosion coefficient Z after Gavrilović)	
	Erosion state before gathering	Erosion state after gathering
Široke Luke		
Area 1, It=21%	Z = 0.41	Z = 0.43
Area 2, It=26%	Z = 0.40	Z = 0.40
Prelesje		
Area 1, It=18%	Z = 0.42	Z = 0.45
Area 2, It=18%	Z = 0.42	Z = 0.42

On all three sample plots, the processes of medium erosion range within the interval 0.40 – 0.42 for erosion before gathering, and 0.40-0.45 for erosion after medicinal plant gathering. After the collection of medicinal plants, the state on these areas did not deteriorate, because the workers were trained to cut the plants at the specified points above the root, and also to leave the predicted number of plants in the aim of biodiversity conservation.

3.2. Setting of time norms for the collection of medicinal plants, for price setting

The manpower time norms for the collection of medicinal plants at the selected localities were determined by the method of chronometry. Before the application of the method for time norms, the technological process had to be studied. It included the breakdown of the complex process into the work operations which are, regardless of the specificity of gathering of individual medicinal plants, the following: preparation of the worker for gathering (scissors, bag, protection gloves), departure to the place of harvesting, gathering of the medicinal plants, measurement of the collected quantity and return to the starting place.

By the implementation of the chronometry method, only the time of useful work is measured – gathering of medicinal plants. The other work operation are not measured, as well as the justified or unjustified delays. The worker who worked on the determination of the time norms of medicinal plant gathering was averagely trained and experienced for the application of the selected methods, precise in filling the data in the prepared form and he was cognisant of the complete technological process. The worker, whose work was measured, was averagely motivated, skilled in his work and he worked with moderate rate. The determination of time norms required a relevant number of measurements, so the adopted value is realised in practice with the required probability.

Figure 2. Sample plot 2 in the area of Široke Luke in the Jeloviška Reka basin

The conditions under which the measurement was performed were recorded before the measurement of the work on the collection of medicinal plants. The most important natural factors affecting the realisation of the results are the slope and the climate-meteorological conditions. In addition to the above conditions, a significant effect was also assigned to technical-technological, organisation-economic and ergonomic conditions.

Table 2 presents the results of measurement of the time of gathering medicinal plants by chronometry, as well as unit prices of gathering obtained based on the net hourly wage of the II category worker for the area of Stara Planina.

Figure 3. Sample plot 1 in the area of Prelesje in the Dojkinovačka Reka basin

Figure 4. Sample plot 2 in the area of Prelesje in the Dojkinačka Reka basin

Table 2. Necessary times for the collection of medicinal plants with unit prices

General conditions	Species	Time norm Nv h/kg	Net hourly wage worker din/h	Unit price din/kg
Široke Luke				
site: plot 1 (25 m2)	Thym us janckae Galium verum Hypericum perforatum	1.45 0.55 0.22	30 30 30	43.50 16.50 6.60
site: plot 2 (25 m2)	Potentilla erecta Hypericum perforatum	0.39 0.67	30 30	11.70 20.10
Prelesje				
site: plot 1 (25 m2)	Thymus janckae	1.58	30	47.50
site: plot 2 (25 m2)	Hypericum perforatum Galium verum Achillea crithmifolia	0.28 0.37 0.33	30 30 30	8.40 11.10 9.95

The interest of the inhabitants of Stara Planina for making a living in this way rises, by all means, together with the interest of the wider community to make this area not only the centre of tourism, but also the centre of production of safe food by the principles of sustainability. The above research should by all means be extended to other species which have market propulsive character, i.e. to those that produce a higher profit. First of all, they are: blueberry, juniper, then hip, elder, blackberry.

3.3. Future market prospects and ecological aspects of medicinal plant production and processing

The potentials of Mt. Stara Planina are by all means higher than the gathering and drying of medicinal plants. The opportunities of some forms of processing, such as the production of essential oils, are seen as a good prospect.

Market attractive programmes based on the local raw-material sources which could be realised in this area in future, are: (1) Aetheroleum Juniperi; (2) Aetheroleum Salvia off.; (3) Aetheroleum Helychrisi; (4) Aetheroleum Mentha pip.; (5) Aetheroleum Hissopi; (6) Aetheroleum Angelicae.

The market competition of the above products is high, it is based on the comparative advantages of rich resources and emphasised export capacity. The level of export prices on the world market, in a relatively long time series, has been stabilised at about the following price levels: (1) Aetheroleum Angelicae: 1050 EUR/kg; (2) Aetheroleum Hyssopi: 200 EUR/kg; (3) Aetheroleum Juniperus: 125 EUR/kg; (4) Helychrisi Oleum: 50 EUR/kg; (5) Aetheroleum Salvia: 55 EUR/kg; (6) Aetheroleum Mentha 44 EUR/kg.

Based on the supposed scope of processing, and based on the diversity of the proposed oil assortment, the structure and number of employees in an oil processing plant is as follows: (1) Plant manager: 1; (2) Plant technician - IV degree: 1; (3) manipulative workers - II degree: 3; (4) Maintenance: electro-mechanic 1; (5) workshop fitter: 1; (6) Boiler house: 2. Total number of employees: 9.

The above data refer to the work in one shift, and they include also the engagement of professionals in the plant laboratory.

The structure of essential oil utilisation is wide-ranging, which means the diversification of the demand. This is reflected in a proportionally great number of users, which use essential oils as the ingredients in their production and in final products. Among them, the significant users are: "Zorka" Šabac; "Merima" Kruševac; "Luxol" Zrenjanin, as well as some foreign firms with convertible payment: "Janausek" Trieste; "Indena" Milano, Italy; "Fincelberg" - Germany; "Dragocco" Germany; "Robertet" - France; "Kvest" - Holland; "Dicroce" - Holland.

In addition, essential oils, as well as the components of essential oils, are also used in meat-processing industry, spice industry, as well as in the industry of aloholic and non-aloholic drinks, by which the list of potential purchasers of these products is significantly enlarged.

From the ecological spandpoint, the proposed programmes and the Plant are completely positive. The technological process is of the closed type, so that there is no direct waste during the process in the sense of atmospheric pollution. The waste material is of organic origin and it is readily decomposed. The plant residues after the distilation can be used for organic fertilisers (to this aim, leaf, above-ground parts, flowers and roots can be used). Waste water from this process does not contain any harmful synthetic chemical substances. Based on the nature of the process, a very small quantity of waste water is expected, because a closed system of water circulation can be constructed.

4. CONCLUSION

Sustainable harvesting of medicinal plants is of exceptional significance for the area of Stara Planina, both from the aspect of conservation of natural resources, and from the aspect of profitability.

The interest of the inhabitants of Stara Planina for making a living in this way rises, by all means, together with the interest of the wider community to make this area not only the centre of tourism, but also the centre of production of safe food by the principles of sustainability. This research should be widened also to other species which have a market propulsive character, i.e. to those that produce a higher profit. First of all they are: blueberry, juniper, then hip, elder, blackberry.

In addition to medicinal plant harveting and drying, essential oils production is seen as a good prospect in this area, which can ensure both an inflow of foreign currency and the healthy environment.

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CHARACTERISTICS OF SOME VARIETIES OF FLUVISOL WITH FOSSIL SOIL IN THE CENTRAL DANUBE BASIN

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Abstract: *In the order of hydromorphic soils, class of undeveloped soils, the variety of fluvisol with fossil soil is a special soil formation. Its basic characteristic is the method of formation, which is divided into two phases. Fossil soil is formed in the initial phase, while in the final phase, the alluvial sediment is deposited over the fossil soil. The thickness of the recent sediment and the particle size composition vary mainly depending on the intensity of the river transporting power. Due to the above specificities of these soils, this study presents the morphological characteristics, physical, water-air and chemical characteristics of some buried fossil soils in the alluvial plain of the Central Danube Basin.*

Key word: fluvisol, two-layered variety with fossil soil, alluvial plain.

1. INTRODUCTION

Fluvisols occupy the areas in the inundations of large rivers and their tributaries. In the hydromorphic order, in the class of undeveloped soils, fluvisol is the only typical representative. The river inundation (in the narrower sense floodplain) is conditionally divided into three genetic parts: riparian, central and pre-terrace part. These genetic parts, due to the change of river competence in time, are often of mosaic character, so they are difficult to define in space. In our country, these genetic parts were identified by *Šumakov, (1960)* in the inundations of the rivers Sava and Drava, where he found the regularity of the effects of pedogenetic processes in the occurrence of different systematic soil units. Later on, *Herpka (1963, 1965)* defined their specific topographic-hydrological character. Already at that time it was observed that the most significant role in the formation of soil floodplain is that of the dynamics of river flooding and the transporting power of suspended material (fluvial sedimentation). The formation of these soils, especially the formation of genetic horizons (humification, humisation), is often interrupted by fluvial sedimentation. For this reason, these soils are characterised by a pronounced variation of textural composition (bedding) in the vertical section of the solum, and by a frequent occurrence of several humus horizons, and not rarely also the developed soils buried by the new recent sediments.

Živanov and Ivanišević (1986, 1990) designate fossil soils as a special ecological-production unit within the class of undeveloped hydromorphic soil. In their study of the soils of Ravi Srem, *Ivanišević and Grbić*, (*1992*), found several ecological production units of different buried developed soils on different bedrocks: fossil humogley on alluvial sediment, fossil humogley on loess-alluvium, fossil alluvial semigley, fossil semigley on loess-alluvium and fossil semigley on loess.

The formation of these soils proceeded in two phases. In the first phase, the developed (now already fossil) soils were formed, while in the second phase, the recent alluvial sediment

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was deposited and is currently being deposited over the already formed soil. The thickness and the particle size distribution of recent sediments depend on the river transporting power, the duration and the frequency of flooding. Such soils at the level of the variety are called two-layered soils with fossil soil *(Škorić, et al. 1973, 1985)*, i.e. special soil formations: "sicht " soils (*Scheffer et Schachtschabel, 1966, after Ivanišević and Grbić 1992*), bisequent soils, i.e. buried fossil soils *(Živković et al. 1972)*.

2. STUDY AREA

The research was performed in the part of the Central Danube Basin, on the area of FE Novi Sad, in MU Dunavske Ade. On this area, four representative soil profiles were selected in the zone of forest regions: Susečke forests, Begeč forests, Petrovaradin forests. All the above soil profiles are in the flooding zone. The altitude of the study area is from 74 to 78.5 m, with a pronounced micro relief. The bedrock is alluvial sediment, gleyed in the lower layers. The average temperature of the area is from 10.0 to 11.4°C with the annual precipitation sum of 626.6 mm, and relative humidity averagely about 77%. The plant communities belong to the complex of alluvial hygrophilous forests (*Jović, et al. 1991*), i.e. soft broadleaves.

3. MATERIAL AND METHOD

On the selected soil profiles, the genetic morphological characteristics were determined, and the disturbed soil samples were taken for the laboratory analysis of physical and chemical characteristics by the following methods:

- Determination of particle size distribution by international B-pipette method, sample preparation with Na-pyrophosphate method (group of authors 1997);
- Determination of humus content by Turin's method, Simakov's modification (1957);
- Determination of CaCO3 content by volumetric method, by Scheibler unit calcimeter;
- Determination of pH in water and KCl by electrometric method with combined electrode on Radiometer pH meter;
- Determination of nitrogen content by Kjeldahl method;
- Determination of readily available phosphorus and potassium by Al-method, Egner-Riehm-Dominigo.

4. RESULTS AND DISCUSSION

4.1. Morphological characteristics

Fluvisols have a series of specificities in the morphological appearance of the profile. Namely, the systematic units of this type, at the lower hierarchical level (variety), often have the developed soil in the lower part of the profile, or the occurrence of several humus horizons, overtopped by recent sediments. The thickness of recent sediments in the analysed profiles varies between 25 and 108 cm (Table 1). Their particle size distribution ranges within the interval loamy sand - sandy loam - loam, which shows the pronounced bedding.

In addition to the upper, or the youngest Aa horizon, the fossil humus horizon Ab can cover one or more layers of the recent sediment. The basic formula of these soils can be represented by the following expression: Aa-Ab-IGso...nGr, or Aa-IGso-Ab-IIGso...nGr, i.e. Amo-IGso-IIGso-Ab_1-Ab_2Gr. On the vertical section of the profile of these soils, the fossil humus horizon is distinguished by the dark, gray – black colour, with the particle size distribution in the interval from sandy loam to clay loam. Below it are most often found the layers of the lighter textural classes, with the pronounced oxido-reduction processes. Sometimes, as in the profiles No. 2 and 4, the deepest fossil humus horizon is gleyed, so it makes the real gley Gr sub-horizon.

In the study soils, it is clearly seen that the formation of humus horizons was re-interrupted by fluvial sedimentation, because of which the developed soil was never formed. The morphological characteristics of the analysed soils clearly reflect the typical layered fluvisols.

Particle size distribution

This soil is characterised by an increased percentage of the silt and clay fraction in the recent humus horizon, which was formed by the floods in the recent time period. The higher content of these fractions indicates that the flooding intensity was lower. The fossil humus horizon has a still higher percentage of silt+clay fraction, which often exceed more than a half of the percentage of all other fractions.

In these varieties, because of frequent floods, the soil could not be formed completely, due to the action of fluvial sedimentation. The main characteristic of these soils is the occurrence

Table 1. Particle size composition of fluvisol variety with fossil soil

Horizon	Depth (cm)	Coarse sand >0.2 mm %	Fine sand 0.2-00.2 mm %	Silt 0.002 -0.0002 mm %	Col. clay 0.002 mm %	Total sand >0.02 mm %	Total clay <0.02 mm, %	Textural class
Profile 1: Susečke forests, compartment 8/c								
Aa	0-35	0.2	65.4	25.2	9.2	65.6	34,4	Sandy loam
Ab	35-70	0.7	40.5	43.2	15.6	41.2	58,8	Loam
IGso	70-135	0.3	81.7	12.0	6.0	82.0	18,0	loamy sand
IIGso	135-190	1.3	42.7	39.2	16.8	44.0	56,0	Loam
Average		0,6	57.5	29.9	11.9	58.2	41.8	
Profile 2: Begeč forests, compartment 11/k								
Aa	0-20	8.2	37.0	40.4	14.4	45.2	54.8	Loam
IGso	20-45	1.8	55.4	28.4	14.4	57.2	42.8	Sandy loam
Ab	45-90	1.1	64.8	19.2	14.8	66.0	34.0	Sandy loam
IIGso	90-150	1.1	82.5	11.2	5.2	83.6	16.4	Loamy sand
IIIGso	150-200	0.4	82.8	11.6	5.2	83.2	16.8	Loamy sand
Ab2	200-220	0.1	31.1	36.8	32.0	31.2	68.8	Clay loam
Average		2,1	58.9	24.6	14.3	61.1	38.9	
Profile 3: Petrovaradin forests, compartment 31/c								
Aa	0-12	11.1	58.5	21.6	8.8	69.6	30.4	Sandy loam
IGso	12-25	2.6	84.6	8.4	4.4	87.2	12.8	Loamy sand
Ab	25-50	1.0	27.8	49.2	22.0	28.8	71.2	Loam
IIGso	50-80	1.5	59.7	27.6	11.2	61.2	38.8	Sandy loam
IIIGso	80-120	7.1	88.5	2.4	2.0	95.6	4.4	Sand
Average		4,7	63.8	21.8	9.7	68.5	31.5	
Profile 4: Petrovaradin forests, compartment 32/c								
Aa	0-40	2.6	35.4	40.4	21.6	38.0	62.0	Loam
IGso	40-55	1.4	85.8	7.2	5.6	87.2	12.8	Loamy sand
IIGso	55-108	1.0	38.6	41.2	19.2	39.6	60.4	Loam
Ab1	108-145	0.5	12.3	54.4	32.8	12.8	87.2	Silty clay loam
Ab2	145-180	0.1	31.5	35.6	32.8	31.6	68,4	Clay loam
Average		1,1	40.7	35.7	22.4	41.8	58.2	

of fossil humus horizons and the pronounced bedding. This fact is confirmed also by the high content of the fraction of fine sand in layers above the fossil horizon, which are buried by the new layers of sediment. This occurrence is especially visible in the profiles where there are two fossil humus horizons, which are multiply buried by recent sediments, so the soil formation process of these soils was interrupted several times.

4.2. Chemical characteristics

The chemical characteristic of these soils is a marked variation of the humus content per horizons i.e. layers. The horizons which are the richest in humus are the recent humus horizons, with the intensive process of humification which is related to the elevated inflow of organic matter. The other layers, especially those layers which are richer in fine sand, are weakly humous, except the layers which are directly below the humus horizon where a mild increase is evident, due to the leaching of humus substances. Also, in these soils there is a marked increase of humus in the fossil horizon, which indicates the interrupted pedogenesis of these soils.

Table 2. Chemical characteristics of fluvisol variety with fossil soil

Horizon	Depth (cm)	CaCo3 %	pH		Humus %	N %	P2O5 mg/100g	K2O mg/100g
			H2O	KCl				
Profile 1: Susečke forests, compartment 8/c								
Aa	0-35	19.9	7.8	7.5	2.05	0.074	10.6	7.2
Ab	35-70	19.5	7.9	7.4	2.78	0.105	11.4	10.0
IGso	70-135	23.3	8.1	7.8	0.92	0.020	5.6	4.0
IIGso	135-190	24.7	8.2	7.7	1.20	0.047	10.6	8.4
Average		21,8	8.0	7.6	1.7	0.06	9.6	7.4
Profile 2: Begeč forests, compartment 11/k								
Aa	0-20	18.6	7.8	7.1	4.12	0.211	9.4	13.2
IGso	20-45	16.9	8.2	7.2	1.85	0.081	6.6	7.2
Ab	45-90	10.5	8.3	7.5	2.35	0.070	8.0	6.4
IIGso	90-150	24.3	8.6	8.1	1.63	0.010	4.2	3.6
IIIGso	150-200	23.9	8.4	7.9	0.44	0.014	3.6	4.0
Ab2	200-220	4.2	7.9	7.1	2.31	0.008	16.0	14.8
Average		16,4	8.2	7.5	2.1	0.07	7.8	8.2
Profile 3: Petrovaradin forests, compartment 31/c								
Aa	0-12	14.2	7.7	7.3	4.31	0.150	14	10.4
IGso	12-25	17.1	8.3	7.9	0.65	0.012	4.8	2.4
Ab	25-50	22.2	8.2	7.5	2.13	0.086	6.4	10.4
IIGso	50-80	20.9	8.3	7.7	0.92	0.023	4.2	8.8
IIIGso	80-120	16.7	8.5	8.3	0.57	0.004	3.2	3.6
Average		18,2	8.2	7.7	1.7	0.05	6.5	7.1
Profile 4: Petrovaradin forests, compartment 32/c								
Aa	0-40	15.9	8.0	7.3	3.93	0.197	8.8	15.6
IGso	40-55	16.3	8.4	8.0	0.70	0.010	3.2	3.2
IIGso	55-108	25.1	8.2	7.4	1.40	0.072	7.2	12.0
Ab1	108-145	12.5	8.0	7.2	2.62	0.110	11.4	14.0
Ab2	145-180	1.67	7.8	7.1	3.76	0.020	9.4	8.8
Average		14,3	8.1	7.4	2.5	0.08	8.0	10.7

Also, these soils are characterised by a high content of carbonates in the recent sediment and in the fossil part of the soil, and in the profiles with two fossil horizons, in the second humus horizon, the percentage of carbonates decreases, which points to the leaching of carbonates into the deeper layers, i.e. points to the age of the second humus horizon, i.e. on the potential occurrence of the developed soil in the deeper parts of the profile.

2. CONCLUSIONS

Based on the study results, the following conclusions can be made.

- The main characteristic of these soils is the occurrence of several humus horizons per profile depth, the pronounced bedding of the recent layers, as well as the layers below the fossil horizons.
- Particle size distribution of the recent sediment ranges from loamy sand to loam, while the textural class of the fossil humus horizon is: sandy loam, to clay loam.
- Below fossil horizons, there are layers of different thickness and textural class (bedding), which is the characteristic of the class of undeveloped (hydromorphic) soils.
- These soils are strongly to very strongly calcareous, with a weak to moderately weak alkaline reaction of the soil solution.
- The recent humus horizons are in the class of rather humous, while the fossil humus horizons of these soils are poorly humous.
- The content of total nitrogen in the recent sediment and in the fossil humus horizon is moderate to good, while the content in the layers below the fossil A horizon is very poor to poor.
- The recent humus horizon and the fossil humus horizon are poor to moderately poor in readily available phosphorus and potassium, while the other layers (Gso) are very poor to poor.
- From the aspect of the systematics, based on its characteristics, the study fluvisols is the closest to the variety: two layered variety with fossil soil.

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SECTION 3

SILVICULTURE YESTERDAY, TODAY, TOMORROW

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Abstract: *The significance of the close to natural silviculture aiming at the state optimisation, to ensure the normal function of the natural environment in modern hazardous conditions is pointed out, as well as the global significance and the effect of forests as the stabilising factors of the biosphere function.*

Nowadays, in the conditions of increasing ecological crisis at the world level forests, as multifunctional ecosystems, have a special role in the regulation of the natural environment and balance of the interrelated natural elements. To meet this demand, forests have to be rationally managed, i.e. properly tended and regenerated. The state of forests in Serbia, as the consequence of historical factors, but also the attitude to this natural resource, can be assessed as being at the lower satisfactory limit, if the criteria are the degree of conservation, productivity, vitality and quality.

Many international conferences have emphasised the need of a more rational forest management, i.e. specific silvicultural approaches. Silvicultural activities have to be based on close to natural management, and the type and intensity of operations depend on the functions which forests have to perform. The close to natural silviculture consists of the sustainable and economically justified silvicultural measures, adapted to natural processes, tending to biodiversity conservation, genetic variability, naturalness, enhancement of the state, optimal utilisation of the site potential and increase of forest productivity. In this way the needs of forest protection and the designation of greater areas of protected forests are decreased. The silvicultural measures aiming at the forest state optimisation have to be based on their present state, risk of abiotic and biotic factors and on their significance for the fulfilling of the expected functions. The main silvicultural measures, under the application of the appropriate silvicultural methods depending on the concrete site conditions and stand characteristics, are the increase of the forest cover area, enhancement of the forest state, change of silvicultural forms and the reclamation of degraded forests. In this way forest stability and vitality would be ensured and simultaneously, and in the best way, the all the expected forest functions would be fulfilled.

1. INTRODUCTION

The significance of silviculture in Serbia changed throughout the historic periods of social development in general, and therefore also in our forestry. When forest cover in Serbia was huge and the population number low (till the middle of the 19th century), natural forests could satisfy all the needs of the society, so it is understandable that in such historical and economic conditions, the development of silviculture was not necessary. However in time, forest destruction became so great that the demand for wood surpassed the potentials for its production. This motivated the human interventions in the natural forest regeneration and the attempt to direct forest development in the desired direction, as it had already been done with agricultural crops, by developing silviculture as a science in the field of forestry. From that period till the nineties of the last century, forest management became multifunctional and, in addition to production, the other – so called multiple use forest functions had an important role.

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The concept of forestry sustainable development in Serbia, which was promoted by the end of the last century, includes the multifunctional (integral) forest management, taking into account sustainable management, improvement of forest, state, conservation of forest ecosystem biodiversity and the protection of special natural resources.

In this connection, the role of silviculture changed and its significance is increasingly emphasised from the aspect of the enhancement of forest state.

The above management principles are well known and applied in the countries with developed forestry. The aggravating and restricting circumstances in forestry for the fulfilment of the above goals in Serbia is the degradation of forests and forest lands, or their devastation over large areas, caused by numerous factors. Forest state is often unsatisfactory regarding stand state, quality, stability, vitality, health, etc. The consequences are the unsatisfactory forest productivity, ecological and social functions. On the other hand, the potential improvement of such conditions points to the seriousness of the future dealing with this problem, and the need of their reclamation is the task of forestry science and profession (Krstić, 2006)

The implementation of these principles in the practical forest management in Serbia, where more than 50% of the total growing stock is privately owned, is conditioned by several problems of implementing the necessary measures: the readiness of private owners to accept the multifunctional management and the period (rate) of adoption and implementation, to see the forest only as a source of livelihood, the subventions as the motive for accepting the changes of the attitude to forest, etc.

The intensive industrialisation threatens the natural environment by the contamination with various pollutants in the form of ait pollution by gaseous agents, mineral dust, heavy metals, sooth, smoke, etc. The humanity has in a way adopted the destructive productivity, because the highly developed technology is simultaneously the greatest "producer of pollution". If the disturbance of the environment is the price which should be paid for the fast technological development, environmental protection cannot be considered an act of benefaction, but a necessity. Consequently, "ecological revolution" should follow the industrial revolution, aiming at the conservation of the conditions for human existence. In such conditions, the role of the multifunctional ecosystem - forest is irreplaceable, as the stabilising factor of the balance between the tendency to increase environmental pollution (degradation), possibility of improving the state and ensuring the normal functioning of the natural environment. The need for multifunctional forest management is increasingly important and, for this reason, in future smaller areas under forest will have the priority function of wood production, and the multiple use functions will become increasingly significant: protection-regulation, sanitation-hygiene, recreation-health-tourism, aesthetic-ornamental, etc. The adverse effect of pollutants from the atmosphere on the forest is very complex. The intensity of the effect of harmful gases, in addition to the individual species resistance and vitality, also depends on the concentration, toxicity and the duration of the pollutant activity, as well as on the general conditions of the environment in which they occur. The direct effect consists of the damage to assimilation organs, because of which they decline, which leads to the decrease of vitality, increment and finally to tree dying (Krstić and Stojanović, 1999).

The realisation of the above tasks starts from the following, generally known assumptions:

- silvicultural measures are planned and implemented in harmony with the stand development stage and the laws of the natural process of tree development;

- in untended, silviculturally neglected stands, the number of the best quality trees is reduced, and the retarded trees depending on tree species, stagnate for some time and finally they die;

- the decisive parameters in the selection of the appropriate felling as tending measure are: the differentiation of trees, their management significance, development tendency, quality and health;

- in silvicultural felling, it is necessary to evaluate the silvicultural role of the trees, the best quality trees are selected, and felling is performed to their benefit,

One of the basic tasks of forest science and profession is the improvement of the existing forest state, especially from the aspect of their economic and ecological significance. In the selection of silvicultural measures, thanks to the great coeno-ecological and structural diversity of the forest, there should be no schematics, they should be selected based on the really and comprehensively analysed stand state and based on the defined functionally optimal state in the concrete site conditions.

2. SILVICULTURE YESTERDAY

Silvicultural principles changed through different epochs of silviculture development. Before the time of Hartig, the silviculture (thinning) in the modern sense was not mentioned, only the removal of superfluous trees was prescribed by forest regulations. Hartig introduced the term thinning in the professional references and he gave the first guidelines on thinning in 1791. The foundations of modern principles of silviculture were laid by Cotta, 1817, who insisted on the removal of the trees that prevent the development of superior trees. Heyer in 1854 supplemented Cotta's principles by the famous slogan: "early, moderately, frequently". The concept of silviculture changed depending on the goal of management - production of the maximum possible wood volume, or production of the wood volume of the best quality. The trees of considerably larger sizes can be produced by high thinning in a short time, but in this way, because of the more intensive canopy thinning, the trees develop large crowns and stems of wider growth rings, which reduce the stem quality (S. Jovanović, 1988).

From the total area of coppice and other forms of degraded forests in the growing stock of Serbia, it is clear that the basic task of forestry is to convert the greater part of these forests into the high silvicultural form, i.e. to undertake forest reclamation. The methods and directions of forest conversion are determined by scientific and professional methodologies reported in numerous scientific papers scientific and professional conferences. The methods and procedures of solving this complex issue of forest economy are: conversion, restitution, substitution and reconstruction. In practice often, the simplest solution is the substitution, i.e. a poor coppice stand is removed by clear cutting which is followed by afforestation with another, mostly pioneer tree species, without much thought about the economic and ecological justification of this procedure. There are cases of substitution with pine even on the best-quality sites, which was justified by good increment and high productivity of the species. The reclamation of degraded forests, which has so far been performed on large areas, was often performed without the established priority policy and without the clear scientific and professional attitudes. There are almost no examples in practice of reclamation procedures in which coppice forest was converted into high forest, because the majority of such forests were in the younger development stages, so that it is now that the conversion of the silvicultural form can be performed.

3. SILVICULTURE TODAY

In the identification of the necessary measures of forest management in general, it is always necessary to start from the general objectives of forest management which emphasises that forests must be maintained, regenerated and utilised in order to ensure the sustainability and increase the yield and production, conserve and increase their value with the simultaneous development and intensifying of multiple use functions. To protect a forest does not mean to exclude it completely from harvesting; protection serves as a regulator of the intensity of utilisation.

The proposal of management (silvicultural) measures for the optimisation of these forests is based on their present state, their significance for the fulfilment of the expected forest functions and the risk of abiotic and biotic factors. The following well-known facts should be taken into account:

- Large-scale areas (several thousand hectares) lead to economic and technical problems, forest accessibility (forest roads), labour force, etc.

- Long-lasting production process (up to 120-160 years), i.e. long periods are necessary for the significant changes of forest state,

- Very limited possibility of speeding up the production process, which depends on the biological characteristics of the trees.

The state of our forests, as well as the nonuniform percentage of the stands of some categories from the silvicultural aspect, imposes the need to define the appropriate silvicultural operation in each concrete situation, which is the result of silvicultural demands. Starting from the presented state and analysis of the growing stock, it is necessary to carry out the following silvicultural measures:

1. Increase the area under forest - because the present forest cover percentage is not satisfactory.

2. Change the silvicultural form - coppice forests should be converted into high forests, and the present ratio in favour of high forests should be considerably improved.

3. Reclamation of degraded coppice forests and scrubland – improve the state of these forests by the appropriate silvicultural procedures depending on the concrete site conditions and stand characteristics (conversion, restitution, substitution, reconstruction).

4. Improvement of the state of high forests – the unsatisfactory state of high forests, low value of the average wood volume per hectare for the concrete stage of development, low volume increment, absence of tending measures and regeneration process, etc. – are the elements which impose the urgent undertaking of the appropriate cutting in each concrete situation and the implementation of timely professional tending measures in all forests. As opposed to Cotta's and Heyer's principle "early, moderately and frequently", the today's principle of "late, intensive and rare" thinning is unacceptable and not sustainable. It must be started early and then it can be intensive and rare.

By the appropriate necessary silvicultural interventions, the existing forests should be improved to the optimal state, by which their stability and vitality will be ensured and, simultaneously, the fulfilment of all the expected forest functions will be optimally realised (Krstić, M., Stojanović, Lj., 1999).

3.1. Necessary measures for the improvement of forest state

The proposal of management (silvicultural-reclamation) measures for the optimisation of the state of these forests should be based on their present state, significance for the realisation of the above expected forest functions and the risk of abiotic and biotic factors. The following facts should be considered (Krstić and Stojanović, 1999; 2003):

Aiming at the improvement of the present state of the existing growing stock, the appropriate silvicultural-reclamation cuttings, should have the following direction:

1. Measures for the establishment of new, good-quality stands - well-timed natural regeneration of the mature stands and when needed also the artificial regeneration.

2. Measures for the improvement of the state of the existing forests:

– well-timed and regular felling as the measure of forest tending,
– rehabilitation of high degraded forests,

– conversion of coppice forests into a higher silvicultural form (reclamation of degraded forests).

3.1.1. Rehabilitation of high forests

High forests are in an unsatisfactory state on significant areas, which is reflected in the high percentage of thin mature stands without seedlings, and with retarded old trees – seed trees. Such an unfavourable state can be restored by the appropriate silvicultural measures (Stojanović and Krstić, 2000; Stojanović, *et al*, 1996), which consist of the following:

– repair planting of less thin stands

– natural regeneration with the implementation of the necessary auxiliary measures in the regeneration,

– artificial regeneration of stands by sowing seeds or planting the seedlings,

– urgent removal of the remaining seed trees from the regenerated stands.

Very often, ill-timed and even unprofessional felling in natural regeneration causes the absence of natural seedlings and weeding. To eliminate these disadvantages in natural regeneration in each concrete stand, it is necessary to correct the classical methods of regeneration and the methods of planning and management by the selection of the appropriate methods of natural regeneration, thinning time and intensity. The desired goals should not be only the production of wood volume, but also all other multiple-use functions. If this is not implemented, the spontaneous forest regeneration will often continue. The appropriate conditions for natural regeneration will be created primarily thanks to the favourable natural conditions in the region.

The silvicultural situation in one compartment (stand) is rarely identical and homogeneous, which imposes the implementation of several different silvicultural procedures that can encompass all the diverse environmental conditions and silvicultural situations, based on the principle of the free method of silviculture. Silvicultural needs are concrete, and different operations are needed in individual parts of the stand (Stojanović and Krstić, 2000, 1996; Milin, 1988; Krstić and Stojanović, 2003):

- in thin stands without seedlings, or with an insufficient number of seedlings, natural regeneration should consist of different regeneration cuttings e.g. group-selection regeneration method, and in some cases clear cutting or artificial regeneration. In such situations, most often successful natural regeneration cannot be expected without the implementation of auxiliary measures. Each further delay and waiting leads to further weeding and creation of more unfavourable conditions for seedling survival. Therefore, it is necessary first to form or shape the area for regeneration, appropriate for the bioecological characteristics of the concrete species, with the implementation of auxiliary measures – soil preparation in the year of the expected abundant seed yield. The existing openings or more heavily thinned parts of the stand should be united and shaped by size and form, appropriate for the regeneration and more efficient application of necessary measures. The places for the formation of regeneration areas depend on the stand state, site conditions and the organisation of harvesting – necessity to apply the combined systems of group-selection regeneration (Femelschlag).

- in the stands with remaining old trees – seed trees, the most urgent method is final cutting for the removal of seed trees from the stand, to release the young stand from the direct and detrimental shade. Any further postponing of felling, even in the case of causing damage, aggravates the state and felling becomes more difficult. After cutting and removal of such individual trees, it is not necessary to plant the gap, because it will close sooner or later. In the group-selection distribution of »seed trees«, the gaps are considerably larger (larger than the tree height), so the fast closing of the stand canopy and the gap is not possible, and it is necessary to fill the openings by artificial intervention.

- the stands of seed origin at the poorest sites are very poor quality and there is no biological or economic justification for classical management. They are most often protection forests and their reclamation is not foreseen in this time period.

3.1.2. Artificial regeneration and the establishment of new forests

In the parts of high forests, on the areas without natural regeneration and where natural regeneration is not possible, artificial forest establishment should be done by sowing the seeds or planting the seedlings. Regeneration by sowing the seeds is faster, simpler, cheaper and safer, because it is close to natural regeneration, however it is limited by the demand for a great quantity of seeds and by the low effect - success, so it is less utilised.

The Spatial Plan of Serbia projects large-scale works on afforestation of treeless lands and agricultural areas affected by erosion, the establishment of suburban forests, rehabilitation of spoil banks, etc. By such afforestation, forest cover percentage in Serbia should increase to 31.7 % by 2010 and to 41.4% by 2050. As based on the spatial distribution, agriculture and forestry are the basic uses of land production potential, their delimitation is necessary in the aim of rational land use. Pursuant to the global division, the land is classified into the land for agricultural production (I - III quality class), and land for forest production (VI, VII and partly VIII class), while classes IV and V represent the boundary areas. Based on this categorisation in Serbia, forests are potentially intended on the additional area of 6,903 km^2 (VI, VII and VIII quality classes). As these land categories are characterised by steep and very steep slopes, skeletoidness, erosion and flood hazards, their afforestation can simultaneously ensure both the protection and the production function.

The intended forest cover percentage will also be achieved (Jović, *et al.*, 1995) by the establishment of shelterbelts on the area of 992 km^2, protection forests in headwater areas, along the rivers and water storages on about 2,047 km^2, protection forests along the roads on 527 km^2, immission protection forest belts in the "circles of radiation" of emission sources on 368 km^2, rehabilitation of spoil banks of opencast mines of mineral ores on 339 km^2, and establishment of suburban forests on the area of 527 km^2.

3.1.3. Reclamation of degraded forests

The reclamation of degraded forests is based on basic laws and principles of forest management in general and should be done by the implementation of the most modern methods of agroengineering, silvicultural works and protection. In this way, the increase of productivity of various forms of degraded forests is initiated and activated and simultaneously other benefits are ensured and intensified in the form of multiple use forest functions.

The reclamation of degraded forests should be based on the basic principle that relatively conserved autochthonous coppice forests on the conserved sites should be kept in their autochthonous form, but the forests should be converted into the high silvicultural form by conversion measures. The more degraded forests of poor quality and reduced productivity should be subjected to an accelerated reclamation procedure. They should be replaced by the appropriate clear cutting methods, and by the introduction of autochthonous species of better genetic characteristics, or of other species which are compatible with the ecological conditions.

The subjects of reclamation are: forests with insufficient percentage of valuable tree species; forest of unsatisfactory stand state; regenerated stands of seed origin without the principal species; coppice forests; low density forests (thin); forests of low productivity, low quality, created as the result of species succession (birch, hornbeam, aspen); scrub and brushland; declining and dying forests and forests of poor health. If forest state cannot be reclaimed by classical silvicultural procedures (degraded or devastated forests), appropriate reclamation procedures should be applied in the aim of improving - reinstating the state and the value.

For the selection of the reclamation method, it is significant to determine the degree of the site (land) degradation and the degree of forest degradation (production, quality, health, composition, origin, etc.).

Regardless of the great number of unsolved problems of the reclamation of degraded forests and other wooded lands, it can be concluded that its rate, dynamics and methods are not the main problems, because reclamation depends significantly on the economic background, i.e. on the community interest in the problem and the investment policy in this respect.

The selection of forest reclamation methods requires the identification of both the degree of site (land) degradation and the degree of forest degradation.

To identify the stand state of degraded forest stages, it is important to determine the following: stand canopy - tree layer and shrub layer, percentage of economically important tree species and their dimensions, stand density, productivity based on wood volume and increment, tree quality, and the potentials of natural regeneration. These indicators are the decisive factors of the stand reclamation methods (Krstić M., Stojanović, Lj., 2004).

4. SILVICULTURE TOMORROW

4.1. Scenarios of future events

Based on the research of numerous scientists worldwide, there are several scenarios of global and regional climate changes. Working Group II WMO and UNEP - Intergovernmental Panel on Climate Change (1990), based on the data in professional references, developed the following scenario of potential climate changes in future: double effective CO_2 increase in the atmosphere by 2025 - 2050, global increase of mean temperature by 1.5 to 4-5°C, unequal global distribution of the temperature increase – low increase in tropical regions (up to the half of the global values), and higher increase in polar regions – double increase of the presented values, higher sea level about 0.3-0.5 m by 2050 and 1 m by 2100, together with higher ocean surface temperature between 0.2 and 2.5°C.

The above global and regional climate changes could be manifested in the following way:

- Double increase of immission;
- Ecological conditions will be changed, resulting in physiological and biological changes of the living world;
- More difficult forest adaptation and increased forest degradation;
- Threatened survival of numerous flora and fauna species, especially in the most vulnerable areas (semi arid) where many species are closed within their biological boundaries;
- Many life communities adapted to certain conditions will be threatened and in stress hazard (terrestrial ecosystems, montane, polar, insular communities);
- Socio-economic consequences.

The impacts of predicted climate changes on forests are the following:

- New temperature regime, - forest ecosystems will be more vulnerable;
- Lower precipitation – stands will be more vulnerable to great changes in precipitation, particularly to their decrease in arid and semiarid areas;
- Changes of forest soil – the climate will be warmer and more arid, so forest ecosystems and many species will have a limited development and survival;
- Forest characteristics – threatened stability, forest composition will be disturbed, reduction of moisture is critical for the development of seedlings and roots causing stress situation in that stage, more intensive reclamation measures will be required;
- It will be necessary to carry out new research of the relations between plants and sites, bioecological characteristics of the species, genetic variability, impacts of climate changes on forests, etc.

The interaction between climate changes and air pollutants will be the cause of special stress to trees (forests) in the form of: increased damage from insects and fungi; reduction of genetic diversity in forests; increase of hazard and damage from forest fire; reduction of tree vitality; decline (dying) of some tree species. Therefore, forest management measures should be adapted to the changed environmental conditions; new knowledge and strategy in silviculture will be needed; the formation of new climate zones will cause the formation of new forest ecosystems (significant changes in forest composition) and it will be necessary to define the new ranges of distribution, etc. (Krstić and Stojanović, 1999).

4.2. Significance and role of silviculture in future

Sustainable forest management means the harmony between conservation, harvesting and improvement of forest state, i.e. the balance of utilisation of natural resources, site production potentials and genetic potentials of the forest tree species, with the maintenance of forest productivity, stability and vitality, protection of forest ecosystems and natural biodiversity, as well as the existing natural rarities – relic and endemic species and forest communities.

The significance of special-purpose forests in the ecological system is high, and the general interests indicate that they are an increasing concern of the widest spheres of the society. Many international Conferences (Rio, 1992; Helsinki, 1994; Montreal, 1995; Kyoto, 1997; Arhus, 1998, etc.) inter alia, emphasise the permanent need for the more rational forest management and the designation of new areas of special-purpose forests, as well as the need for specific silvicultural procedures. An important task of silviculture set by the multiple-use forestry and the new efforts, is to ensure the balance between production potentials with the conservation and utilisation of the forest ecosystems. The greatest productivity and balance in the given environmental conditions can be achieved only by the implementation of multiple-use silviculture. The role and significance of special-purpose silviculture is reflected inter alia, in the ensuring of stability, sustainable development and conservation of forest ecosystem biodiversity (Govedar *et al*, , 2006).

Forest improvement can be realised by the intensive tending and protection of the existing forests in all development phases; by natural and artificial regeneration of existing forests; by reclamation of degraded and devastated forests – by the conversion of coppice forests into high forests, reclamation of coppice forests of poor quality, brushland and other vegetation forms, by reclamation of degraded forests of seed origin, by reconstruction of poor forests.

Because of the percentage and state of degraded forests, their reclamation cannot be performed in a short time period on large areas; it must have a long-scale character. Therefore, it is necessary to decide on the urgency and priority degrees and then to select the area for reclamation. Urgency is decided based on the stand quality, and priority is dictated by the site conditions. Stand reclamation is more urgent if the stand quality is better. The stands with favourable site conditions also have the priority. The order of urgency and priority is the following: poor stands on good site, then good stands on good site and finally poor sites on poor site. The scope of reclamation works in degraded forests (conversion period) depends primarily on financial means, management goals and the possibility of evaluating the performed works, taking into account the sustainable management (Krstić M., Stojanović, Lj., 2004).

4.2.1. Significance of silviculture for forest biodiversity protection

Protection of natural rarities and special nature is also a significant measure of forest enhancement in Serbia. 564 protected areas of different sizes, and 678 plant and animal species with the status of natural rarities are under the regime of special protection. Protected areas cover 34 % of the total area of Serbia. Special protection encompasses: five National Parks (Kopaonik, Tara, Djerdap, Fruška Gora, Šar Planina), 20 Regional Nature Parks, 114 Nature Reserves, 378 Monuments of Nature, 23 Monuments of Landscape Architecture, 6 Park Forests, etc., as well as 251 plant species and 427 animal species as natural rarities (Kuzmanović, 1996). In the Republic of Serbia, there are 433 protected areas on altogether 515 thousand hectares, which is about 6% of the territory of Serbia. The prevailing forms are National Parks, Nature Parks, Special Nature Reserves, Landscapes of Exceptional Characteristics, etc. SE "Srbijašume" is the manager of 97 protected areas on about 246 thousand hectares (Aleksić and Jančić, 2006).

Nature protection includes the identification of the specific regime of utilisation; protection of biodiversity (conservation of genetic, species and ecosystem biodiversity), monitoring of biodiversity and risk factors, appropriate measures of biodiversity conservation. The concept "active protection" was promoted by the end of the last century to avoid the trap of formalism and declarative advocating of nature protection, only to increase the number and the area of protected areas, in the aim of preventing the regression succession of vegetation and its destruction. Their state can be improved by the selective implementation of the appropriate silvicultural measures, which are adapted to natural processes – the so-called anthropogenically supported spontaneous succession.

The general characteristic of all silvicultural works based on close to nature management includes the application of biodiversity factors, and this issue (Govedar *et al.*, 2006) was defined by the Helsinki process, 1994. It was emphasised that biodiversity protection and conservation are among the basic factors of forest ecosystem stability, in which silvicultural works have a very significant role. For biodiversity, *inter alia*, it is important to know the state of threatened plant and animal species in special-purpose forests. Namely, most of these forests are under a strict or more tolerant regime of protection. In such forests, the higher number of threatened species can be an indicator of forest biodiversity depletion, caused by inappropriate silvicultural operations. A similar indicator of the changes in negative direction is also the decrease of the ecological value of the forest. Both factors should be continuously monitored, and silvicultural operations should be directed to the prevention of the undesired phenomena. The mosaically distributed remains of natural and conserved forests can serve as the only reference base for biodiversity research of silvicultural orientation (Kouki, 1994). In such forests, the important indicators are the changes of the number and percentage of threatened species. Their depletion (decrease of biodiversity) can be considered as a warning to change the silvicultural measures in order to conserve biodiversity. There are two approaches in the maintenance of forest biodiversity:

- protection of vulnerable and rare ecosystems (mainly in special-purpose forests),
- practical implementation of close to nature silviculture in the existing commercial forests.

In the aim of maintenance of a high level of biodiversity in commercial forests, it is necessary to implement close to nature silviculture, for which there are no unique silvicultural models for practical implementation in the aim of forest biodiversity conservation and enhancement. The implementation of silvicultural operations in commercial forests in the aim of biodiversity conservation and increase leads to extra expenses and lowers the production effects of the forest. Thus, e.g. the concept of specific ecological silviculture in the area of Lübeck in Germany, which was introduced in 1994 and supported by forest certification, encompasses the following: no clear cutting, no introduction and no afforestation with allochthonous species, only selection felling is allowed, 10 % of forest area is converted into natural reserves and protection forests, 10 % of the total volume of dead trees should remain in the forest.

Naturalness is the base of stability of the special-purpose forests. Natural forests are, from the silvicultural aspect, according to the majority of authors, taken as the models for the realisation of close to nature silviculture (Leibundgut, 1978, 1982, 1986 and 1989; Schütz, 1986, Korpel, 1995 etc. - after Govedar, *et al.*, 2006). According to the above authors, it should be identified which type of natural forest can be used as the model for the comparison in the management of commercial forests. Although natural forests are generally accepted as the base for the realisation of close to nature silviculture, the concept and the idea of the natural forest model should be defined (Leibundgut, 1986; Strum, 1993, etc.). Namely, the concept of close to nature silviculture started developing by the end of the 19th century, and there are different methods of describing the idea, depending on the emphasis placed on "culture" – silviculture or "nature" – nature forest (Schütz, 1999). Today this concept should be widened, so as to include the significance of biodiversity and natural potentials which are economically justified. Consequently, **the close to nature silviculture includes the sustainable and economically justified silvicultural activities limited by natural processes, where natural site potential should be optimally utilised for biodiversity conservation, genetic variability, naturalness, enhancement of forest state and increase of productivity**. As the basic lesson for silviculture, after Leibundgut (1982), the research of virgin forests first of all aims at the closer look at the aspirations and ways of nature, because it is the basic assumption of the rational silviculture. It (nature) instructs us how far and in which direction silviculture can freely apply the influential natural forces in harmony with the classical, but still valid, Parade's idea reported more than a hundred years ago (1862): "**The basic maxim of silviculture is to imitate the nature, to accelerate its action".** Today, according to silvicultural standpoint, the more intensive the implementation of close to nature silviculture in forest production, the lower the need for the comprehensive forest protection and for the singling out of large areas of protected forests (Parviainen, 2003, after Govedar, *et al.*, 2006).

Regarding the significance of silviculture in future, Nikolić and Stojanović (1990) and Stojanović *et al.* (1999) report that too great laicizing and potentiation of the forest function problem has created the false dilemma: intact or commercial forests, in which the intact forests are the forests that develop spontaneously, i. e. virgin forests. The centuries-long silviculture and scientific research shows that «virgin» is not the most stable form of forest stand, and that often they do not support the optimally essential forest functions, primarily the regulation and protection. On the other hand, professional forest management ensures the stable, healthy and highly productive forests. High production of biomass is indirectly and economically the most important forest function, with which all other functions are in a high direct correlation. Proving and insisting on other forest functions has become the symbol of prestige, outside the real interest and sense, so the exaggerations in this sense misinform the public and stimulate the irrational conflict with the forestry profession. Undoubtedly, protection-regulation functions are of high significance, but two questions can be asked: are the multiple use forest functions really opposed to production function, and what is the economic significance of wood production? Often se production functions are not objectively presented and they are underestimated. The energy function of wood, as ecologically the cleanest energent, is not calculated. In some developed countries, it is assumed that the percentage of wood in energy balance is about 10%, while in our country it is undoubtedly multiply higher, because wood is the energy raw material of a great part of the population.

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EFFECT OF DIFFERENT SILVICULTURAL TREATMENTS ON THE DEVELOPMENT AND INCREMENT OF MIDDLE-AGED BEECH STANDS ON MT JUŽNI KUČAJ

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Abstract: *This paper analyses the effect of different silvicultural treatments on the development and increment of middle-aged beech stands on Južni Kučaj during the period 1986 - 2002. The stands are situated in similar site conditions and they are close regarding the age and age of the dominant trees, but their structure and increment are significantly different. At the end of 2002, the ratio of total increment volume on permanent sample plots was 1 : 1.88 and it is most likely caused by the different silvicultural treatments of the stands from the beginning of their establishment. The comparison of growth elements in 2002 and growth elements in 1985 shows a greater relative increase of the total basal area (143% - 149%) and volume (216% - 219%) on control plots compared to the thinned sample plots where the relative increase of the total basal area was (99% - 132%) and volume (140% - 182%). Under the identical number of future trees on all sample plots, the lowest increase of basal area (192% - 214%) and volume (275% - 301%) was on the control plots, whiles on the thinned plots the increase of basal area was (213% - 232%) and volume (301% - 331%). The results point to a complex effect of different silvicultural treatments on the stand increment in individual development phases.*

Key words: beech, thinnings, effects thinning, Južni Kučaj.

1. INTRODUCTION

As the species of wide ecological plasticity, beech shows great divergence in growth and volume increment under the effect of different silvicultural treatments. Silvicultural treatment, therefore, can have a significant effect on the stand volume increment in the given development phase. Growth and development of beech seedlings is under the direct effect of silvicultural treatments (Bobinac M. 1999, 2002, 2006), and according to the research of adult stands (Ferlin F. 1985, Stamenković V., Vučković M. 1990, Krstić M. 2004, Stojanović Lj, 2003, Stojanović Lj. *et al.* 1985, Bobinac M. 2004, 2006, Stefančik H. *et al.* 1996 etc.) and their comparison, more intensive silvicultural treatments produce higher effects on beech volume increment and tree quality than the extensive silvicultural treatments.

The aim of this study is to emphasise the effect of different silvicultural treatments on growth elements in a middle-aged beech stand, in similar site conditions on Južni Kučaj.

2. STUDY AREA AND METHOD

A middle-aged beech stand was researched on Južni Kučaj (F.A.″Boljevac″, MU ″Gari Veliki Vrh″, compartment 8), on two series of sample plots (II and III), with three sample plots (OP). The stands belong to the montane beech forest (*Fagetum montanum*) on parent rock red

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sandstone and deep to very deep acid-brown soil. The altitude is 700-720 *m*, exposure South-East, and slope for series III is les s than 8°, a nd for series II 15-18°. The trees in t he dominant layer are approximately of identical age. During the first measurement in 1985, the tree age in series II was 40-50 years, and in series III about 50 (Milin Ž., Stojanović Lj. 1986). Sample plots represent the pa rts of the st and which a re similar regarding the space, site, origin and age of dominant trees, but significantly different regarding the stand structure. The differences mainly result from the longer keeping of seed trees on sample plot series II in the phase of stand regeneration and different tending operations (Stojanović *et al.*, 1994). In series II, thinning was in 1985 (O P-1), 1994 (OP-3), and OP-2k was the control area. In series III, thinning was in 1985 and 1990 (OP-1), 1990 (OP-2), and OP-3k was the control area.

Based on the measurement of diameters above 5 cm, in 1985 and 2002, the volume for each sample plot was calculated by volume tables for beech - high forests in Serbia. For each sample plot series, for the state in 1985 and 2002, the altitudinal curves were constructed by the function $h=a\cdot e^{-b/d}+1.30$.

3. RESULTS

Figure 1 shows the altitudinal curves for the state in 1985 and 2002 for each series. Altitudinal curves in series II, in the part of larger-diameter trees, are lower compared to the altitudinal curves in series III, which indicates the lower production level in series II.

Figure 1. Altitudinal curves in 1985 and 2002 for series II and III

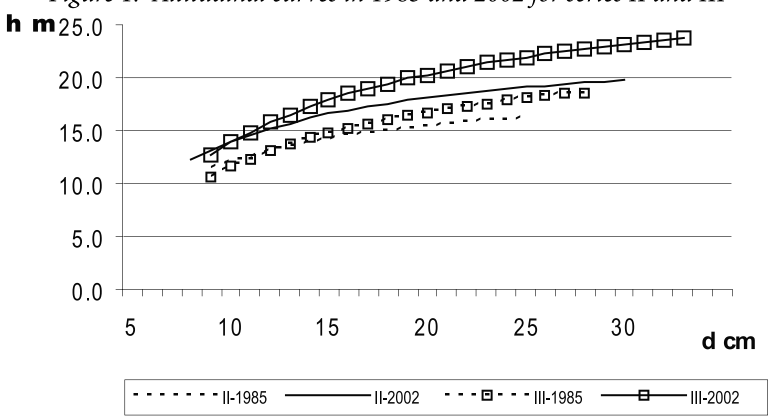

Table 1 presents the total volume in 1995 and 2002 and the total thinning yield in the study period. At the end of 2002, total volume in the analysed series ranged averagely 1 : 1.88 and it can be largely assigned to different silvicultural treatments in the stands, from the period of establishment.

Table 1. Total volume till 2002 and thinning yield in the period 1985-2002

Series II			Series III		
OP	Total volume	Thinnin g yield	OP	Total volume	Thinnin g yield
	m3·ha-1				
1	275.5 (1.14)	34.6	1	444.9 (0.88)	102.8
3	225.7 (0.93)	40.1	2	451.7 (0.90)	56.9
2k	241.5 (1.00)	-	3k	504.0 (1.00)	9.9

Growth elements on sample plots in 1985 and 2002 are presented in Table 2. In 2002 on sample plots under the different treatments in series II, increment occurred on 81.6%-95.1% trees of the total number in 1985, and in series III 69.9%-80.9% trees. At the dominant tree age of 60-70 years in 2002 on sample plots, there were an approximately identical number of dominant trees and a great number of trees with reduced functional characteristics (Bobinac M. 2003).

Table 2. Growth Elements in 1985-2002

Series	Measurement	OP	Total						Future trees					
			N	G	V	Dg	Hg	H/D	N	G	V	Dg	Hg	H/D
			ha-1	m2·ha-1	m3·ha-1	cm	m		ha-1	m2·ha-1	m3·ha-1	cm	m	
II	1985	1	4675	26.6	132.3	8.5	11.1	131	300	3.9	23.7	13.0	13.1	101
		3	4750	23.1	108.9	7.9	10.6	134	300	3.1	17.7	11.5	12.9	112
		2k	4600	24.1	111.5	8.1	10.7	132	300	3.4	19.5	12.2	13.2	108
	2002	1	4100	35.1	240.9	10.5	14.3	136	300	8.6	71.4	19.1	17.9	94
		3	3875	28.2	185.6	9.6	13.6	142	300	7.2	58.5	17.5	17.4	99
		2k	4375	35.9	241.5	10.2	14.1	138	300	7.3	58.7	17.5	17.4	99
III	1985	1	3432	38.8	243.4	12.0	13.1	109	300	6.7	47.5	16.8	15.6	93
		2	3582	36.5	217.5	11.4	12.7	111	300	6.0	41.5	16.0	15.3	96
		3	k 3440	37.9	225.3	10.6	12.1	114	300	7.3	53.2	17.6	15.9	90
	2002	1	2399	38.4	342.1	14.3	17.4	122	300	14.3	150.3	24.7	21.9	89
		2	2899	44.6	394.6	14.0	17.2	123	300	13.3	137.5	23.8	21.6	91
		3 k	3060	54.1	494.1	14.7	17.7	120	300	14.0	146.3	24.4	21.8	89

The comparison of growth elements on individual sample plots in 2002 and in 1985 (Table 3) indicates that in series II, the increase of the total basal area (149.1%) and volume (216.6%) was the highest on the control plot (OP-2k). The increase of basal area (131.8) and volume (182.1) was lower on OP-1 which was thinned in 1985. Basal area (121.9) and volume (170.3) increased minimally on OP-3 which was thinned in 1990. In series III, the increase of total basal area (142.6%) and volume (219.3%) was the highest on the control plot (OP-3k). The increase of basal area (122.5) and volume (181.5) was lower on OP-2 which was thinned in 1985, and basal area (99.0) and volume (140.5) increased minimally on OP-1 which was thinned in 1985 and 1990. However, when the values of growth elements of future trees are compared on individual sample plots in 2002 and in 1985, the lowest increase of basal area (191.8 % - 214.4 %) and volume (275.2 % - 300.7 %) occurred on the control plots, while on differently thinned sample plots, the increase of basal area (213.4 % - 231.9 %) and volume (301.0 % - 331.3 %) was higher.

Table 3. Growth elements in 2002 compared to the state in 1985 (%)

Series	OP	Stands					Future Trees				
		N	G	V	dg	hg	N	G	V	Dg	Hg
II	1	87.7	131.8	182.1	123.5	128.8	100	218.9	301.0	146.9	136.6
	3	81.6	121.9	170.3	121.5	128.3	100	231.9	329.6	152.2	134.9
	2 (k)	95.1	149.1	216.6	125.9	131.8	100	214.4	300.7	143.4	131.8
III	1	69.9	99.0	140.5	119.2	132.8	100	213.4	316.4	147.0	140.4
	2	80.9	122.5	181.5	122.8	135.4	100	221.7	331.3	148.7	141.2
	3 (k)	70.5	142.6	219.3	138.7	146.2	100	191.8	275.2	138.6	137.1

4. DISCUSSION

Because of the lack of favourable conditions for development, i.e. the absence of the adequate silvicultural treatments in different beech stand development phases, the growth and development of trees was slowed down. From the aspect of production, to reach the equal wood volume production, it is necessary to prolong the rotation in the stands with slowed development. Due to the delayed thinning, the increase of basal area and volume at the stand level is discontinuous during the long time intervals because of the absence of growth acceleration on the remaining trees. Pursuant to the effects of thinning in the untended middle-aged stands, the primary subjects of tending are the dominant trees and future trees.

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A CONTRIBUTION TO THE STUDY OF SILVICULTURAL NEEDS OF HORNBEAM (*CARPINUS BETULUS* L.) STANDS IN THE AREA OF SREM

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Abstract: *Silvicultural needs of the juvenile hornbeam stands which are the degradation consequences of the most productive common oak sites in the area of Srem were studied. The study was focused on a 32- year-old stand, on a permanent sample plot sized 0.25 ha. At the age of 32, the total number of trees was 2708 per ha, basal area 29.06 m²/ha, and volume 224.6 m³/ha. The highest percentage was that of hornbeam, 73% per tree number and 60.4% per basal area. The stand was in the phase of the beginning of the abundant yield of the most represented tree species. The analysis of the elements of biological-qualitative structure in the upper storey (BP-1) shows that the number of trees was 1260 per ha (46.5%), out of which 408 trees (32.4%) was of good quality stem (KD-1), 80 trees (6.3%) with regularly developed crown (RK-1), and 240 trees (19.0%) with irregularly reduced crown (RK-2). The above data point to the need of selective thinning in the aim of the increase of the stand quality and value, i.e. the establishment of the optimal structure for the reconstruction of the actual stand form. In the experiment, the stand was selectively thinned, thinning weight 50% per tree number, 37.8% per basal area and 35.4% per volume. Total removed volume was 79.5 m³/ha.*

Key words: *Carpinus betulus* L., stand structure, silvicultural needs, thinning, Srem.

1. INTRODUCTION

Pure hornbeam stands and the stands in which hornbeam dominates on the most productive common oak site in Srem are degraded formations resulting from the inadequately performed regeneration of high common oak - hornbeam forests in the past. In contrast to the other areas, where the common oak forests were reconstructed by the substitution of tree species (Hinkov G. *et al.*, 2005), in the area of Srem, this process was characterised by the direct substitution of stand form. The regeneration of common oak forests and the reconstruction of their degraded forms in the area of Srem were based on the implementation of different preparatory measures (Bobinac M. 1999, Bobinac M. *et al.*, 2004 a, b). The silvicultural aspect of the reconstruction of the predominantly pure hornbeam stands, before the beginning of hornbeam fructification, is based on the reduction on the coppice regeneration potential of the felled trees, and after the hornbeam seed production, the synchronised reduction of the coppicing potential and the generative regeneration before the introduction of acorns. After the phase of hornbeam seed production is reached (Bobinac M., Rađević V., 2005), the reconstruction dynamics is decided based on the knowledge of the stand structure and development, its productivity and economic value, i.e. suitability for reconstruction in the different phases of development. The aim of this

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study is to point to the structure of the predominantly pure hornbeam stands in the juvenile development phases and to define their silvicultural needs.

2. MATERIAL AND METHOD

The research was performed in the 32-year-old stand in which hornbeam is the dominant species. The permanent sample plot (OP-1), size 0.25 *ha*, was selected in the well-stocked part of the stand on the site of the forest of common oak, hornbeam and narrow-leaved ash (*Carpino-Fraxino-Quercetum roboris, subass. caricetosum remotae* Jov. *et* Tom. 1978 - on semigley to semigley lessivé in the non-flooded region, Jović *et al.*, 1989/1990). Until the above age, there was only one tending measure – cleaning at the age of 24 years. On the sample plot, we measured the diameters at breast height of all trees above 5 cm, and the trees were classified by biological position, stem quality and crown form, according to the three-degree classification: biological position (BP): upper layer (1); intermediate (2); under wood (3), stem quality (SQ): good (1); medium (2); poor (3), crown form (CF): regular or reduced by the crowns of the adjacent trees by less than 25 % of its circumference (1); reduced on one side by the crowns of the adjacent trees by 25-50% of its circumference (2); multiply reduced by the crowns of the adjacent trees by more than 50% of its circumference (3).

The tree distribution by diameter was defined by the following parameters: mean diameter ($\bar{d}$ and d_g), standard deviation (S_d), coefficient of variation ($K_v\%$), coefficient of skewness (α_3) and coefficient of kurtosis (α_4). The construction of height curve was based on the function $h=a*e^{-b/d}+1.30$, and the volume is determined based on the volume tables for hornbeam (Špiranec M. 1975). The silvicultural demands and the experimental thinning were defined based on the analyses of biological structure and quality structure.

3. RESULTS

The growth elements and the total structure of trees per diameter degrees on the sample plot are presented in Table 1. Of the total 2708 trees per ha, with basal area of 29.06 m^2/ha and volume of 224.6 m^3/ha, hornbeam has the highest percentage 73.0% per tree number and 60.4% per basal area. Of other tree species, the percentage of common maple is 22.1% per tree number and 26.5% per basal area, narrow-leaved ash 2.7% per tree number and 11.8% per basal area and common elm 2.2% per tree number and 1.3% per basal area.

The dominant layer (BP-1) accounts for 46.5% of trees and 73.2% of basal area, and the underwood layer (BP-3) accounts for 39.6 % of trees and 17.3 % of basal area. The percentage of intermediate trees (BP-2) is 13.9 % per tree number and 9.5% per basal area (Table 2). Mean diameter of trees in BP-3 is 0.53 and in BP-2 0.68 of mean diameter of the trees in BP-1. Mean trees of all BPs are characterised by a high degree of taper *h/d*=114-183.

Table 3 presents the distribution of trees per diameter in the categories of crown development. In the stand, 5.9 % of trees have regularly formed crowns, 20.2% have unilaterally reduced crowns (RK-2), and 73.9 % of trees have significantly reduced crowns (RK-3). Mean diameter of RK-3 trees is 0.55, and that of RK-2 trees is 0.80 of the mean diameter of RK-1 trees.

Table 4 presents the distribution of trees per diameter in the categories of stem quality. In the stand, 15.1 % of trees have good-quality stem, 23.0% have the stem of medium quality, and 61.9 % trees have low-quality stem. Trees with good-quality stem account for 20.2 % of the stand volume, and trees with low-quality stem account for 44.0 % of the stand volume. Trees with good-quality stem are characterised by a higher degree of taper (*h*/*d*=122) compared to the trees with medium and low-quality stems (*h*/*d*=92-107).

Table 1: Elements of tree growth and structure per diameter.

OP-1	Initial state						Marked trees					
d cm	N ha-1	N %	G m2·ha-1	G %	V m3·ha-1	V %	N ha-1	N %	G m2·ha-1	G %	V m3·ha-1	V %
5	620	22.9	1.92	6.6	11.1	4.9	452	33.4	1.37	12.5	7.9	9.9
10	1320	48.7	10.48	36.1	73.9	32.9	644	47.6	4.86	44.3	34.0	42.7
15	592	21.9	9.86	33.9	77.3	34.4	208	15.4	3.34	30.5	26.0	32.7
20	128	4.7	3.89	13.4	33.5	14.9	48	3.6	1.40	12.8	11.6	14.6
25	32	1.2	1.68	5.8	16.3	7.3						
30	12	0.4	0.85	2.9	8.6	3.8						
35	4	0.1	0.38	1.3	3.9	1.7						
Σ	2708	100	29.06	100	224.6	100	1352	100	10.98	100	79.5	100
	$\overline{d}$ =10.9 cm. sd=4.32 cm. Kv=39.5%						$\overline{d}$ =9.6 cm. sd=3.43 cm. Kv=35.7 %					
	α3=1.07			α 4=6.37			α 3=0.76				α 4=4.98	
	dg =11.7 cm. hg=16.0 m. h/d=136 IVp=7.33 m3/ha						dg =10.2 cm. hg=15.5 m. h/d=151					
							Thinning per N=50.0 %					
Remains	1356	50.0	18.08	62.2	145.1	64.6	Thinning per G=37.8 %					
	dg =13.0 cm		hg=16.4 m		h/d=126		Thinning per V=35.4%					

Table 2: Distribution of trees per diameter in the categories of biological position

d cm	Biological position											
	I				II				III			
	N ha-1	N %	G m2·ha-1	G %	N ha-1	N %	G m2·ha-1	G %	N ha-1	N %	G m2·ha-1	G %
5					12	3.2	0.04	1.5	608	56.7	1.88	37.4
10	524	41.6	5.06	23.8	356	94.7	2.62	94.7	440	41.0	2.79	55.6
15	560	44.4	9.40	44.2	8	2.1	0.11	3.8	24	2.2	0.35	7.0
20	128	10.2	3.89	18.3								
25	32	2.5	1.68	7.9								
30	12	1.0	0.85	4.0								
35	4	0.3	0.38	1.8								
Σ	1260	100	21.27	100	376	100	2.77	100	1072	100	5.02	100
%	46,5		73.2		13.9		9.5		39.6		17.3	
	dg=14,7 cm hg=16,7 m h/d=114				dg =10.0 cm hg=15.3m h/d=153				dg =7.8 cm hg=14.3 m h/d=183			

Table 3: Distribution of trees per diameter in the categories of crown development

d cm	Crown development											
	I				II				III			
	N ha-1	N %	G m2·ha-1	G %	N ha-1	N %	G m2·ha-1	G %	N ha-1	N %	G m2·ha-1	G %
5									620	31.0	1.92	12.1
10	16	10.0	0.17	4.2	232	42.3	2.26	24.8	1072	53.6	8.05	50.9
15	96	60.0	1.77	42.6	240	43.8	3.87	42.6	256	12.8	4.22	26.7
20	28	17.5	0.86	20.7	52	9.5	1.60	17.6	48	2.4	1.43	9.0
25	12	7.5	0.68	16.1	16	2.9	0.82	9.0	4	0.2	0.2	1.2
30	4	2.5	0.30	7.3	8	1.5	0.55	6.0				
35	4	2.5	0.38	9.2								
Σ	160	100	4.16	100	548	100	9.09	100	2000	100	15.81	100
%	5.9		14.3		20.2		31.3		73.9		54.4	
	dg=18.2cm hg=17.3 m h/d=95				dg =14.5 cm hg=16.7 m h/d=115				dg =10.0 cm hg=15.4 m h/d=122			

Table 4: Distribution of trees per diameter in the categories of stem quality

d cm	Stem quality											
	I				II				III			
	N ha-1	N %	G m2·ha-1	G %	N ha-1	N %	G m2·ha-1	G %	N ha-1	N %	G m2·ha-1	G %
5					4	0.6	0.02	0.2	616	36.8	1.90	14.5
10	220	53.9	1.97	33.5	308	49.4	2.76	27.3	792	47.3	5.75	43.9
15	164	40.2	2.79	47.5	228	36.5	3.74	37.0	200	11.9	3.34	25.5
20	12	2.9	0.37	6.3	52	8.3	1.62	16.0	64	3.8	1.90	14.5
25	8	2.0	0.44	7.5	20	3.2	1.05	10.4	4	0.2	0.20	1.5
30	4	1.0	0.30	5.1	8	1.3	0.55	5.4				
35					4	0.6	0.38	3.8				
Σ	408	100	5.87	100	624	100	10.10	100	1676	100	13.09	100
%	15.1		20.2		23.0		34.8		61.9		44.0	
	dg=13.5 cm hg=16.5 m h/d=122				dg =14.4 cm hg=16.7 m h/d=92				dg =10.0 cm hg=15.4 m h/d=107			

4. DISCUSSION

The structure of the study stand is the consequence of the way of stand formation. The growth elements in the 32-year-old stand (*N*=2708 trees per ha, G=29.06 m^2/ha, V=224.6 m^3/ha) point to a rather high productivity. The analyses of elements of biological-quality structure in the upper layer (BP-1) shows that the number of trees is 1260 trees per ha (46.5%), of which 408 trees (32.4%) are with good-quality stem (KD-1) and 80 trees (6.3%) with regularly developed crown (RK-1) and 240 trees (19.0%) with unilaterally reduced crown (RK-2).

The elements of biological-quality structure point to the potential and justification of the implementation of selective thinning in the study phase of stand development, in the aim of increasing the stand quality and value, i.e. aiming at the formation of favourable structure for the stand reconstruction. The weight of selective thinning was 50 % per tree number, 37.8 % per basal area and 35.4 % per volume. Total felled volume was 79.5 m^3/ha, which can be evaluated as the real silvicultural need of the stand.

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EFFECT OF THE TERMS OF PRODUCTION AND PLANTING ON THE SURVIVAL OF EURAMERICAN POPLAR CUTTINGS

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Abstract: *The reactions of the clones on the factors affecting the rooting success are one of key parameters in nursery production of black poplars.*

The effect of different terms of cutting production and planting on the survival in July and at the end of the production cycle was studied for two clones of Euramerican black poplars (I-214 and Pannonia) on three different soils.

The results point to the superiority of the earlier terms of planting of cuttings compared to the later terms. On sandy soils, the differences of the survival percentage between the analysed treatments (terms of cutting production and planting) are greater for both clones, while on more loamy soils, the differences are lower (clone I-214) or are not significant (clone Pannonia). The study results show that the clone Pannonia compared to the clone I-214 has a higher "plasticity", i.e. a greater number of the applied treatments of cutting production and planting terms render the same survival percentage.

The differences of the reactions of the two study clones to the applied treatments point to the possibility of adaptation of nursery technology and nursery production organisation to the specificities of the cultivated clones.

Key words: nursery production, survival, cutting, poplar.

1. INTRODUCTION

Nursery production is the first technological phase in the process of poplar plantation establishment and cultivation. One of the key problems of nursery production is the rooting of poplar cuttings and the production of the maximum possible number of rooted cuttings for the successful establishment of poplar plantations.

According to references, rooting success depends on several factors: the clone characteristics and the cutting physiological state (Kovačević, 2003), the soil characteristics (Ivanišević, 1993) and the moisture supply in the rooting period (Živanov, *et al.*, 1985), etc. The spring rooting period is essential for the survival of cuttings (Kovačević, 2001, 2003), while the differences between the genotypes exceed the differences between the species within the section *Aigeiros* Duby (Guzina, *et al.*, 1997).

The aim of this study is to analyse the effects of different times of cutting preparation and planting of two Euramerican black poplar genotypes and the effects of three different soils, on cutting survival.

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2. MATERIAL AND WORK METOD

Two clones of Euramerican black poplar (*Populus x euramericana* (Dode) Guinier) were researched: I-214 (domesticated clone) and Pannonia (registered in 1998). The experiments were established with cuttings 20±2 *cm* long, on three different soils (localities), and with different planting spaces, at the following localities:

1. locality Ljutovo (near Novi Bečej) – sandy soil, planting space for the production of rooted cuttings, types 1/1 or 1/2, – 0.70 x 0.40 *m* or 0.28 m^2 per rooted cutting;
2. locality Lugarnica (near Novi Sad) – sandy-loamy soil, planting space for the production of planting material (cuttings) from one-year-old rooted cuttings – 0.80 x 0.15 *m* or 0.12 m^2 per rooted cutting;
3. locality Šmaguc (near Bački Monoštor, Municipality Sombor) – loamy soil, planting space for the production of rooted cuttings, types 2/2 and 2/3, – 1.65 x 0.30*m* or 0.495 m^2 per rooted cutting.

The main physical-chemical characteristics of the soil to the depth of 50 *cm*, in which the rooting process occurs, are presented in Table 1.

Table 1. Physical-chemical characteristics of the soil to the depth of 50 cm at the study localities.

Locality	$CaCO_3$	pH	Hu-mus	N	P_2O5	K_2O	Granulometric composition				Sand	Clay	Texture class
					[mg/ 100g]	[mg/ 100g]	>0,2	0,2-0,02	0,02-0,002	<0,002	>0,02	<0,02	
	[%]		[%]	[%]			[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	
Ljutovo	2,9	8,1	1,02	0,058	16,6	7,6	0,6	79,8	9,6	10,0	80,4	19,6	loamy-sand
Lugarnica	22,7	8,2	1,77	0,063	7,1	9,6	0,3	52,2	33,7	13,8	52,5	47,5	loamy
Šmaguc	22,6	7,6	1,62	0,307	14,6	12,0	2,1	26,9	51,6	19,4	29,0	71,0	silty-loamy

Eight technological procedures were applied at each analysed locality, defined by the terms of cutting production and planting (Table 2).

Table 2. Technological procedures of the terms of cutting production and planting

Terms of cuttings production	Terms of cuttings planting		
	2 (late March)	3 (early April)	4 (late April)
1 (late February)	T12	T13	T14
2 (late March)	S22	T23	T24
3 (early April)	-	S33	T34

The prepared cuttings were stored in a pit (T) at the temperature of 4 - 12 ^oC till the time of planting, but in two technological procedures, planting was done directly after the cutting preparation (S22 and S33).

The experiments were established in the spring 2005 by the random distribution principle. At the localities Ljutovo and Šmaguc, the experiments were established with 4 repetitions and 50 cuttings in each repetition, while at the locality Lugarnica, the experiment was established with three repetitions and with 30 cuttings in each repetition. During the growth season in the nursery, the usual measures of tending and protection were performed: hoeing and soil loosening, watering (in June and July), preventive treatment by fungicides, pruning of branches and sprouts.

The data were collected in July and at the end of the vegetation (October). The data were processed by a three-way analysis of variance, with the previous transformation of survival percentages ($z=arcsin(\%surviv.)^{½}$). A fixed model of three-way analysis of variance was applied:

$$X_{ijkm} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \varepsilon_{m(ijk)}$$

The effect of the analysed sources of variation was assessed based on their expected variance in the total variation, while the mean values were compared by the test of the least significant differences (LSD) at the risk level of 0.05.

3. RESULTS AND DISCUSION

The study results show that at all the three localities with different planting spaces, the influence of different terms of measurement is not statistically significant (Table 3). This confirms the results reported by Kovačević (2003) that the survival determined in October does not differ from the survival in July. Also, the study planting spaces (canopy closure) do not affect the survival under the applied technological procedures of cutting preparation and planting of both poplar clones, which agrees with the findings reported by Andrašev, *et. al.*, (2002).

Table 3. Three-way analysis of variance and the percentage of the expected variances per localities.

Factor of variability	Analysis of variance						Expected variance [%]			
	Ljutovo		Lugarnica		Šmaguc		Variance	Ljutovo	Lugar-nica	Šmaguc
	df	F	df	F	df	F				
Terms of measurement	1	0.565ns	1	0.835ns	1	0.632ns	σ2α =	0.0	0.0	0.0
Clone	1	8.722**	1	51.505***	1	15.065***	σ2β =	2.0	22.6	13.8
Technological procedure	7	69.772***	7	30.415***	7	5.894***	σ2γ =	72.9	52.7	19.3
Terms of measure. x Clone	1	0.018ns	1	0.167ns	1	0.015ns	σ2αβ =	0.0	0.0	0.0
T. of measure. x Tech. proc.	7	0.025ns	7	0.214ns	7	0.067ns	σ2αγ =	0.0	0.0	0.0
Clone x Techn. procedure	7	4.835***	7	1.914ns	7	1.505ns	σ2 βγ =	8.1	3.3	4.0
Terms of m.x Clone x T. proc.	7	0.008ns	7	0.192ns	7	0.008ns	σ2αβγ =	0.0	0.0	0.0
Error	96		64		96		σ2err =	17.0	21.4	62.9
Total	127		95		127		σ2T =	100.0	100.0	100.0

The differences between the study clones and the technological procedures have a statistically significant effect on the variation of cutting survival. As for the contribution of the expected variances, the effect of technological procedures is dominant, and it decreases starting from the sandy soils (locality Ljutovo) towards the loamy soils (locality Šmaguc).

The effect of different technological procedures of the cutting preparation and planting of the two black poplar clones in October points to the different survival depending on the locality (Diagram 1). A significant difference ($p<0.001$) between the treatments of cutting preparation and planting of both black poplar clones was recorded at the locality Ljutovo (sandy soil) and at the locality Lugarnica (sandy-loamy soil). At the locality Šmaguc (loamy soil), the difference in survival percentage was determined only for the clone I-214 at the risk level 0.05, while it was not determined for the clone Pannonia ($p>0.05$).

The poorest survival at all localities resulted from the planting by the end of April. Still the results obtained at the locality Šmaguc indicate that on some soils, it is possible to get good results even by these technological procedures. These facts are the base for the optimisation of nursery production depending on the specificities of each nursery.

The clone Pannonia, after storing the cuttings in the pit and planting in late March and early April, produces similar survivals of cuttings on all three study soils.

If it is adopted that the criterion of successful percentage of survived cuttings is above 80%, it can be concluded that all technological procedures of the clone Pannonia cutting preparation and planting on loamy soil (locality Šmaguc) produced satisfactory results.

On sandy-loamy soil (locality Lugarnica), only planting in late April results in the survival poorer than 80%. The survival poorer than 80% on sandy soil resulted also from cutting preparation in late February and planting in early March (T13), but it does not differ significantly from the other technological procedures of planting in late March and at the beginning of April.

The survival of cuttings of the clone I-214 is on average poorer than that of the clone Pannonia. On loamy soil (Šmaguc) technological procedures of planting in late March and early April (except S33) make the same homogeneity group by LSD test, and give a satisfactory survival, higher than 80%. On sandy-loamy soil (Lugarnica), the satisfactory cutting survival, i.e. survival higher than 80% is reached only by earlier plantings (S22) and shorter storing in pits (T12 and T23), although they do not differ significantly from the technological procedures S33 and T34. On this soil, a longer storing in the pit (T13) and planting by the end of April (T14 and T24) produces a considerably lower survival percentage.

On sandy soil, only the technological procedure of the clone I-214 with the early cutting preparation and planting (T12) resulted in the survival above 80% and it differed significantly from the other technological procedures. Longer storage (T13) or later planting (T23), as well as the technological procedure without storing the cuttings in the pit (S22 and S33) of the clone I-214 on sandy soil, resulted in the similar survivals of 66.6 - 73.2% and it made the homogeneity group by LSD test. On sandy soil, clone I-214 shows significantly poorer results of cutting preparation and planting by the end of March without storing in the pit (S22) compared to the earlier preparation of cuttings and storing in the pit till the end of March (T12). This points to the favourable effect of storage in the pit on cutting survival.

The above data are consistent with the quantity of readily available water in the soil. Sandy soils can retain a smaller amount of readily available water after snow melting and they lose moisture faster than sandy-loamy and loamy soils (Ivanišević, 1993), so by longer storage or planting in later terms (end of March), the content of moisture in the soil is not sufficient for the successful rooting of cuttings and the survival of rooted cuttings.

The experiment at the locality Ljutovo shows a significant interaction *clone x technological procedure* at the risk level 0.001 (Table 3). At this locality (sandy soil), the best survival is achieved with a shorter storing. The clone I-214 achieves the best planting results in the earlier term (T12), while the clone Pannonia achieves the best planting results in the later term (T23). Clone I-214 has by 23.5% lower survival in the later term (T23) compared to the earlier term (T12), while the clone Pannonia has a lower survival by 10.7% in the earlier term (T12) compared to the later term (T23).

The study results show that the clone Pannonia has a better adaptation than the clone I-214, i.e. a grater number of the implemented terms of cutting production and planting achieve the satisfactory survival percentages. The different reactions of the two study clones to the applied technological procedures of cutting preparation and planting point to the potentials of the adaptation of nursery technology and organisation of nursery production to the specificities of the raised clones (varietal technology). Also, it is clear that the technology of cutting production and planting cannot be prescribed, it should be adapted to the specificities of the study clone and to the conditions of the nursery in which the rooting-bed is established.

The study results show that the effect of the terms of cutting production and planting is very important and that it deserves the adequate attention in the aim of the optimisation of the nursery production technology.

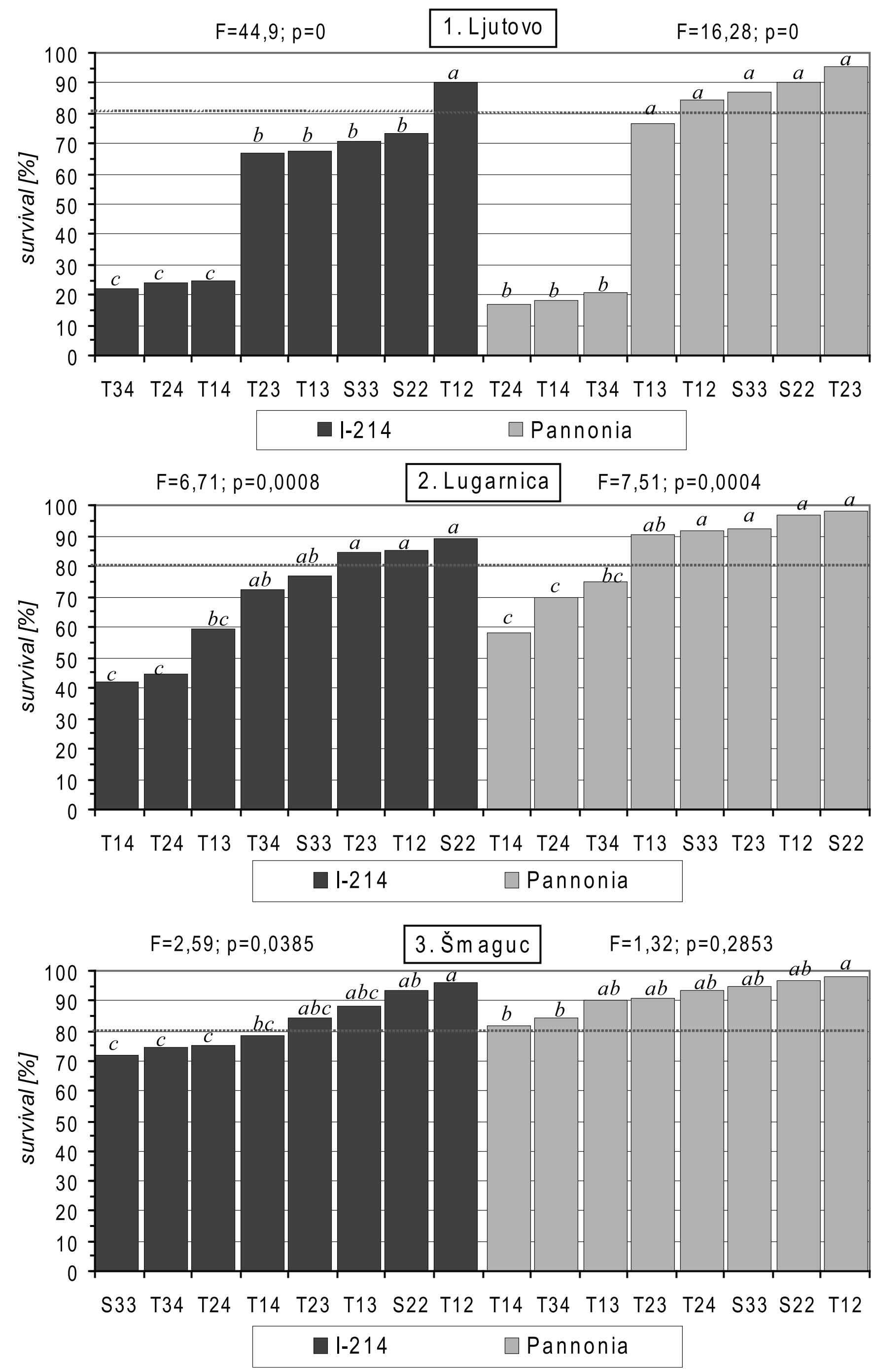

Diagram 1. Survival percentage in October, as per localities, clones and terms of cutting preparation and planting

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CROWN FORM AND QUALITY OF SESSILE OAK TREES IN THE SEEDLING AND SAPLING DEVELOPMENT PHASES AS THE INDICATORS OF SILVICULTURAL NEEDS AND MEASURES

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Abstract: *Crown form of sessile oak trees was analysed in the stands of seed origin in the stages of seedling, early sapling and late sapling, in the area of Majdanpečka Domena, and the possibility of its application as the indicator of silvicultural demands. The stands were tended by liberation cutting, cleaning and the first thinning. The development and the stand transition from one development stage into another were monitored in the period 1994 - 2006. The following elements were analysed: crown base, absolute and relative crown length, crown diameter, the coefficient of crown width and the tree form quotient.*

Key words: sessile oak, crown form, silvicultural demands, silvicultural measures

1. INTRODUCTION

It is known that, from the biological aspect, crown is the most important part of the tree because its structure and its relation to other parts of the tree affect the vitality, and in this sense also all life functions, which is in the end reflected on tree and stand increment and productivity. For this reason, the crown structure has a high significance, as the silvicultural measures can affect the crown formation, i.e. regulate the life space of trees, very efficiently.

Sessile oak forests in the area of Northeast Serbia represent a conglomerate (aggregate) of three sessile oak species: Central European sessile oak – *Quercus petraea* (Mat) Liebl., Transylvanian sessile oak – *Quercus polycarpa* Schur. and Daleschamp's sessile oak - *Quercus daleschampii* Ten., which were previously often equalised and were not specially described, because they are very similar from the aspects of evolution, morphology, anatomy and ecology. Taking into account that, in this area, the above species do not form special pure stands, but occur simultaneously and together, all sessile oak stands in this study are treated as sessile oak forests. Sessile oak forests in this area occur in the altitudinal belt 300-700 (800) m. The orographic conditions are characterised by an intensively differentiated relief with various geomorphological forms: low and medium-high mountains (rarely above 1000 m), with a very distinctive dissection, with sudden alteration of sharp ridges, steep sides and flattened plateaux (Krstić, 1989, 2003).

Based on the above, the aim of this paper is to study the structure and quality of sessile oak tree crowns in the development phases of seedling and sapling and the possibility of their utilisation as indicators of silvicultural needs and measures in the stand.

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2. STUDY AREA AND METHOD

Sessile oak forests were researched in the area of Majdanpečka Domena in Northeast Serbia.

The study area is at the altitude of 500 m, south exposure and slope 22°. Based on the in-depth study of environmental conditions and sessile oak forest communities in this area, it was determined that bedrock is composed of schists (gneiss and phyllites), and the soil is medium-deep acid brown. The stand is typologically defined as sessile oak forest (*Quercetum montanum subass. caricetosum pilosae*) on medium deep acid brown soil on schists (Krstić, M., 1989).

The main characteristics of the climate are conditioned by the geographical position of the area. Basic climate conditions of the study stand altitude (500 m) are as follows: mean annual air temperature is 8.9 °C, during the vegetation period 15.5 °C; annual rainfall 640 mm, during the vegetation period 385 mm or about 60 % of annual quantity. Based on Thornthweite's climate classification, this is the subhumid climate, moister type C_2, and after Lang, the forests are in their climate-physiological (biological) optimum (Krstić *et al*, 2001).

The research was performed in the earliest development phases of sessile oak stands of seed origin – in the stages of seedling and sapling, i.e.: later stages of seedlings, aged 8 years; early saplings 12 years old; late saplings 20 and 24 years old. The stands are tended, i.e. based on the current silvicultural needs, the appropriate silvicultural thinnings were undertaken for each development phase: liberation felling, cleaning, and the first thinning.

The standard working method was applied: the establishment of sample plots and the collection of data during the forest operations. Each sample plot covers one stand of the above development phases of sessile oak forests. The research was performed during the period 1994-2006, i.e. stand development was monitored and the stand transition from one development phase into another.

All trees on sample plots were measured: the diameters and the adequate number of heights for the construction of the height curve. The assessment of crown structure was based on the felling of mean stand trees per basal area. Ten trees were felled per each development phase, and five trees in the oldest one, which altogether amounted to 35 trees, which were measured to determine the crown structure: height of crown base, crown length, diameter of crown base and the greatest crown diameter, and the height of the maximal crown diameter. The biological position of each tree, stem and crown quality were also assessed..

Basic characteristics of the sets – individual development phases, are presented in Table 1.

Table 1. Basic data - tree diameter

Develop. phase	Age (year)	Min (cm)	Max (cm)	Average (cm)	Stand er.	Coef.var. (%)	N/ha
Seedling	8	0,3	0,9	0,54	0,18	32,5	52,000
Early sapling	12	2,0	2,5	2,18	0,17	8,0	32,400
Late sapling	20	4,0	5,6	4,54	0,50	11,1	14,800
Late sapling	24	7,7	9,0	8,24	0,48	5,7	7,100

Data processing was performed by the standard method applied in the research of this type.

The following elements were analysed: tree standing area, absolute and relative crown length, diameter of crown base and the maximal diameter, height of the maximal crown diameter, coefficient of crown width and the tree form quotient. The data were processed by regression analysis, and the ungrouped data were used. Height curves were constructed based on the mean value per diameter degrees. Data fitting was by analytic method, by the implementation of Prodan's functions of growth. The curves of crown height were constructed by the same method. Data fitting was by the second degree parabola and the degree (multiplicative) function.

The statistical analysis performed in data processing was the descriptive statistics, Anderson-Darling goodness of fit test for tree distribution, and T test for the determination of the difference between arithmetical means of data sets (Lovrić, 2005).

3. RESULTS AND DISCUSSION

As the structure of all the analysed stands, based on Anderson-Darling test, is characterised by the normal distribution of trees per diameter and height, by the implementation of T test of the difference of arithmetical means of data sets, i.e. the stand development phases, it was calculated that they differ significantly, which means that they could be treated as different data sets and their characteristics could be separately analysed.

The basic data on the structure of the analysed stands, i.e. different development phases of the juvenile sessile oak forests, are presented in Table 2.

Table 2. Basic data on the stand structure and crown form

Develop. phase	Age	N/ha	Sa (m2)	Dbh (cm)	Hav (m)	Cl		Cw (m)	Ccw	Fq
						(m)	%			
Seedling	8	52.000	0,19	0,54	1,53	0,96	63	0,64	119	273
Early sapling	12	32.400	0,31	2,18	4,05	1,98	49	1,12	51	186
Late sapling	20	14.800	0,68	4,54	6,01	3,21	53	1,72	38	132
Late sapling	24	7.100	1,41	8,24	8,05	4,91	61	2,80	34	98

The presented data indicate that the number of trees (N) after thinning is considerably lower depending on the stand development phase, and it amounts from 52,000 of seedlings, to 7,100 of late saplings (before the first thinning). This shows that thinning weight was approximately 40-50% per tree number. In this way, the standing area (Sa) of a tree is considerably changed, i.e. it is approximately doubled after each silvicultural intervention. This shows simultaneously that mean stand diameters (Dbh) and crown widths (Cw) are approximately doubled, i.e. that there is a proportional relationship between the number of trees and these elements of stand and crown structure. This is a very important indicator for the assessment of thinning weight in silvicultural cutting.

3.1. Structure of tree crowns

Crown length

It is known that crown length is one of the basic and very significant indicators of crown development, and that it increases with age. However, as it depends on several factors – tree species, stand form, stand canopy, density, age, mixture, tree diameter, environmental conditions, etc., this regularity can be disturbed.

The height of the crown base in mature sessile oak stands at the above site increases sharply, approximately up to the diameter class of the mean stand diameter, when it reaches the maximum and starts decreasing. The lower branches of the thinner trees, mainly in the overtopped layer, due to insufficient light quantity, are shed more intensively, so the height of the crown base also increases more intensively (M. Krstić, 1989). In agreement with this conclusion, the height of the crown base in the juvenile sessile oak stands has also a trend of continuous increase.

The general tendency of crown length increase with the tree diameter increase is in harmony with the natural process, i.e. the height growth of trees is faster than the rate of dying of the lower branches. Crown length (Cl) of sessile oak trees in the seedling and sapling development phases of tended stands accounts for 50-60% of the tree height (Table 2).

Coefficient of crown width (Ccw)

For successful thinning, and related to the intensifying of diameter increment, it is very important to know the capacity of crown width of a tree species. It is known that the development of diameter increment is affected by the living space (Ls), i.e. tree growth space, which can be regulated by thinning of the appropriate intensity. After Stamenković *et al*. (1988) in this connection Seebach studied the ratio between the crown diameter and the diameter at breast height and he named it the »coefficient of growth space«.

The coefficient of crown width (Ccw) also changes proportionally with the number of trees, i.e. the tree standing area. It decreases with the increase of tree diameter and it is lower for the trees in the stands of lower density. The difference is more pronounced in thin trees, which are mainly lower in height. The coefficient (quotient) of crown width has the highest value in the seedling stage (Table 2).

In mature sessile oak stands at the above site, the coefficient of crown width, depending on forest type, ranges between 15.2 and 29.1 (Krstić, 1997). The above conclusions are in harmony with the well-known statement that the quotient of crown width is the lowest in the trees in the first biological class, and the highest in the third class (Stamenković *et al*., 1988).

3.2. Structure of tree crowns as the indicator of silvicultural needs and measures in a stand

The structure of tree crown has a high significance in silvicultural works, because it is a very good indicator of silvicultural needs and measures in a stand. Silvicultural measures can very efficiently affect the crown formation, i.e. the regulation of living space.

Crown development is applied as an indicator of the time of the beginning of thinning. When the lower branches start dying more intensively, it is a reliable sign that thinning should begin.

Crown length in the investigated tended sessile oak stands, in the development phases of seedling and sapling, accounts for 50-60% of tree height. Shorter crowns indicate the necessity of silvicultural felling appropriate to the stand development phase, i.e. the need of stand thinning and reducing the number of trees. Crown length can simultaneouly be an indicator of the thinning method. If a faster and more efficient natural shedding of lower branches is desired, felling is mainly performed in the dominant layer. On the contrary, if an excessive reduction of crown length should be prevented, the trees from the overtopped layer are removed and the canopy is thinned. The reduction below 50% of total sessile oak height in the stage of late sapling, points to the need of thinning.

The marked increase of sessile oak crown length with the increase of tree diameter indicates that it is necessary to remove the thinner trees, which have less developed crowns, and therefore a considerably lower increment. Very short and stout crowns of underwood trees indicate a significant deterioration of the conditions for tree development in the overtopped layer of the heliophytic sessile oak, so they should be removed by thinning. A more favourable crown development in the stands of lower density of stocking points to the significant sessile oak potential to develop a strong and longer crown in thinner stands, and in this way to increase the diameter increment. Also in the older sessile oak stands, thinning can significantly intensify the development of tree crowns. It should be born in mind that the degree of stocking in this sense can surpass the effect of site productivity, (Krstić, 1997), which means that the implementation of the same silvicultural thinnings in sessile oak forests in different site conditions is unjustified, and consequently impossible.

Tree form quotient (Fq) bis applied as a significant indicator of thinning weight. As in the tended sessile oak stands it decreases significantly with the reduction of tree number, and as already in the phase of the late sapling it is below 100, this means that thinning can be performed without fear for stand stability.

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DYNAMICS OF NATURAL REGENERATION OF THE MIXED STAND OF BEECH, FIR AND SPRUCE IN VIRGIN FOREST "LOM" IN THE REPUBLIC OF SRPSKA

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Abstract: *In the mixed stand of beech, fir and spruce in the virgin forest Lom, the basic elements of structural form and natural regeneration were researched on a permanent sample plot (P = 1.0 ha). Special attention was devoted to the analysis of the effect of the degree of closure on the process of the stand natural regeneration. The characteristics of the young growth were researched by NAT-MAN (Nature-based Management of Beech in Europe) method. The abundance, age, quality, height increment, height structure, and micro-ecological conditions of plant development were determined. The spatial distribution and the stand regeneration dynamics were analysed and presented by the Stand Visualisation System (SVS) programme. The stand structure is all-aged, close to selection forest in the optimal phase of development. There are 996 trees per ha in the stand, with the mixture proportion beech:fir:spruce = 69.3%:15.7%:15.0%. Average volume is 1216.0 m³/ha, and the mixture proportion (beech:fir:spruce) by volume is 29%:42%:29%. On the sample plot there are 674 young plants of fir, spruce and beech whose height is above 130 cm, and the diameter at breast height is below the taxation limit (5.0 cm). The mixture proportion of the regeneration is fir: spruce:beech = 18%:14%:69%. The regeneration is distributed individually, or in small groups. The interdependence of regeneration characteristics was computed by the regression analysis method, and the effect of micro-site conditions on the young growth characteristics was calculated by the analysis of variance. The average height is maximal in beech and amounts to 182.0 cm, and it is minimal in fir – 11.1 cm. In the height structure, the dominant group are ungrown seedlings which account for 70.0%. With the age, the crown size of beech trees increases rapidly and exponentially, in contrast to the crowns of fir and spruce.*

Key words: virgin forest, regeneration dynamics, Stand Visualisation programme

1. INTRODUCTION

Virgin forests are naturally and spontaneously developed stands in which all processes, and also the processes of natural regeneration, develop without anthropogenic impacts. The study of the regeneration dynamics in the conditions of untouched nature is very significant, because it is possible to compare these processes with the natural regeneration in commercial forests. The temporal and spatial dynamics of natural regeneration differ depending on microsite (micro-habitat) conditions, especially in the conditions of great diversity of orographic and bedrock – soil characteristics of the terrain, as it is the case in the virgin forest Lom. In addition, natural regeneration dynamics also depends on the stand development phase, i.e. on its structure.

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2. STUDY AREA AND METHOD

The research was carried out in the virgin forest Lom, on mountain Klekovača in the Republic of Srpska, in a permanent sample plot, area 1.0 ha, located at the altitude of 1320 m. Parent rock in the study stand consists of Triassic limestones, and the dominant soils are shallow (calcomelanosol and calcocambisol). The stand syntaxonomy is as follows: the alliance *Vaccinio – Piceion* No.- Bl. (1938) 1939 and association *Piceo – Abieti – Fagetum* (Treg.1941) Čolić 1965. Emend. Gajić *et al.*

Two sample plots, area 20 x 20 m, were established with a systematically established network of elementary units in the form of a square, dimensions 1 x 1 m. The characteristics of the regeneration, as well as the microsite characteristics, were measured in the elementary units. The methods applied in this study are the methods of the project NAT–MAN (Nature-based Management of Beech in Europe, 2004).

Total measurement of the young plants with the height above 1.30 cm, and diameter at breast height below the taxation limit of 5.0 cm, was carried out in the area of 1.0 ha. The following data were collected in the elementary units (total 72): tree species, abundance, height, length of the apical and lateral shoots, age, tree quality, crown width, degree of regeneration, degree of vegetation coverage (0.1 - 1.0), degree of stoniness (0.1 - 1.0), degree of rock coverage with mosses (0.1 - 1.0), exposure, and slope of elementary units. The young plants are classified into three categories: height to 50 cm, height from 51 to 130 cm, and height above 130 cm, and diameter at breast height below 5.0 cm.

The data were processed by the methods of regression and correlation analysis and analysis of variance, in order to determine the dependence of the regeneration dynamics and elements on the micro-habitat characteristics. Spatial distribution of trees and young plants is presented by using SVS (Stand Visualization System) software for stand visualization.

3. RESULTS

According to the previous research of the basic elements of stand structure (Govedar *et al.* 2006), the number of trees in the stand with the diameter above the taxation limit of 5.0 cm is 996 trees per ha, with the mixture proportion beech:fir:spruce = 69.3%:15.7%:15.0%. Average volume is 1216.0 m^3/ha, and mixture proportion (beech: fir:spruce) per volume is 29.1%:42.1%:28.8%.

3.1. Characteristics of the young plants and regeneration

The grown-up young trees, with the height above 130 cm, and with diameter at breast height below the taxation limit (5.0 cm) grow individually or in smaller groups (layers). On the sample plot area of 1.0 ha, there are 674 individuals of older grown-up beech, fir and spruce trees with the mixture proportion 68.1%:18.1%:13.8%. The maximal average height is achieved by beech and it amounts to 182.0 cm, while firs have the minimal height of 11.1 cm. The dominant category in the height structure consists of the ungrown-up plants which account for about 70.0%. A characteristic feature is the dominance of beech in the category of grown-up young crop, which is caused by its "social matching" (Mlinšek, 1968) in the lower layer of the stand. This phenomenon was also observed in virgin forests in the previous studies (Šafar, 1953, 1955; Mlinšek and Zupančič, 1974; Govedar, *et al.*, 2006 etc.), but it cannot be considered as the final process of beech becoming the dominant species in virgin forests, as it is the natural process of the change of species (Fukarek, 1965).

In the elementary units of the sample plots 20 x 20 m (OP1 and OP2) there are altogether 18,890 i.e. 18,333 individual young plants, respectively; height up to 130 cm. A considerably higher percentage is that of ungrown-up young plants, height up to 50 cm (more than 83 %), where the dominant species is fir, while beech is the dominant species in the category of the younger grown-up plants.

The most abundant category are the seedlings which account for about 50% and in the seedling category, the dominant species is fir with more than 70%. The seedlings are more represented in OP2, where they account for more than about 80% of the total number of individual young plants. The abundance of young plants per age categories in OP1 is approximately identical. Such age structure of young plants is the consequence of the canopy structure in the sample plots. Namely, in OP2, the canopy is very dense (1.0), while in OP1, it is complete to dense (0.7 to 0.8).

The analysis of the dependence of height and crown width on the age was performed by regression and correlation analysis. The calculated correlation is strong, with the coefficients of determination 0.8 to 0.9. The data were fitted with the second-degree parable, and the following functions were calculated:

- beech height $y = 0.0319x^2 + 0.7945x + 16.082; R^2 = 0.73$
- fir height $y = 0.0239x^2 + 0.6688x + 3.4649; R^2 = 0.93$
- beech crown width $y = 0.6677x^2 - 9.7895x + 47.9666; R^2 = 0.79$
- fir crown width $y = 0.0339x^2 + 0.4844x + 2.7998; R^2 = 0.86$

The study results point to the dynamics of the increase of beech and fir height and crown width, with the age. It is characteristic that beech trees after the age of 10 years, with the increasing age, rapidly increase crown diameter, which is the consequence of beech heliotropic characteristics (Šafar, 1953; Mlinšek, 1974). It was also observed that, at the same age, beech is higher than fir on average for about 10 cm. The increase of fir crown width, with the increasing age, is almost completely accompanied by the increase of height.

The changes of the regeneration abundance depending on the degree of stoniness and the presence of the herbaceous flora in elementary units was determined by the analysis of variance. Elementary units (1 x 1m) were classified in three groups for the comparative studies (treatments), e.g.:

- low stoniness (up to 20 % of rocks per 1m²) and low percentage of ground flora and shrubs - A
- low stoniness with a high percentage of ground flora and shrubs (covered more than 50 % of 1 m²) - B
- high surface stoniness (more than 50% of the area covered with limestone rocks) without ground flora and shrubs – C.

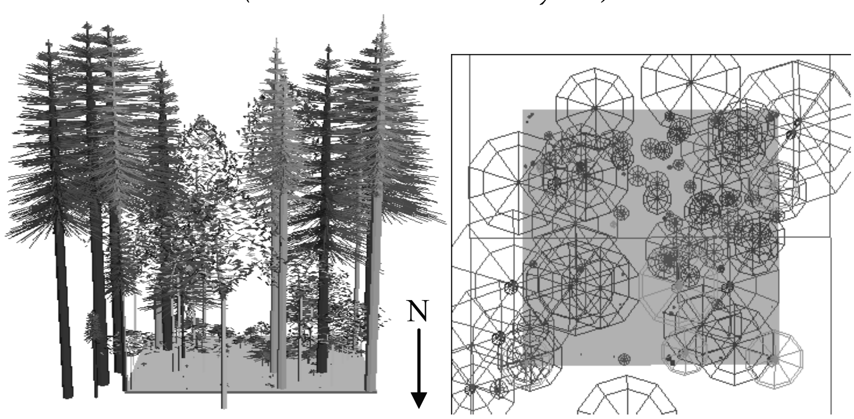
Based on the results of the analysis of variance with unequal numbers of repetitions and F-test for the comparative studies – treatments (A, B and C), it was concluded that there was a statistically significant difference in the total abundance of fir, spruce and beech regeneration. Based on the calculated standard errors, i.e. the difference between the means of treatments i.e. calculated t-values, it was determined that there was a statistically significant difference in the total abundance of young plants between the elementary units with low stoniness and a high percentage of ground flora – B, and the elementary units with intensive surface stoniness – C (Table 2). It is characteristic that there is no statistically significant difference between treatments A and C regarding the abundance of young plants, which can be explained by the complex effect of microsite conditions on elementary units covered by the treatment A, because they are in the complete shade of the old parent trees, which caused a low content of ground flora (mainly *Oxalis acetosella*) and very rare seedlings.

To enable the assessment of the effect of exposure on the total regeneration abundance, elementary units (micro-habitats) were grouped according to exposure into: flat terrain (R), north exposure (N) and southeast exposure (SI). Based on the results of the analysis of variance and F-test, the statistically significant difference was determined in the regeneration abundance depending on the treatments, at the significance level of 5.0%. The results of t-test show a statistically significant difference between the means of the N and SE treatments, i.e. the abundance of young plants in the elementary units (micro-habitats) with SE exposure is significantly higher. This is the consequence of the more favourable light and moisture regimes for the development of young plants (especially firs) observed in OP2.

3.1. Spatial dynamics of the regeneration development

The spatial distribution of trees and young plants presented in Scheme 1 shows the spatial dynamics of regeneration development on sample plots. It is characterised by the more abundant occurrence of young plants in the part of OP1 which is less covered with crowns. OP2 is characterised by the developed lower layer of beech thicket and pole stages, and the degree of coverage with tree crowns is considerably higher (very dense canopy). The dominance of beech in the lower, underwood layer in OP2 is caused by the process of "beeching", while fir seedlings are abundant in the regeneration category. These processes of the alternation of tree species in the long-term development cycles in virgin forests are a characteristic phenomenon in virgin forests of beech, fir and spruce (Šafar, 1953, 1965; Fukarek, 1965; Matić, 1979; Matić, *et al.*, 2001; Stojanović, *et al.,* 1995, 1999 etc.).

Scheme 1: Spatial distribution of trees and young growth in OP1
(SVS – Stand Visualisation System)



4. CONCLUSION

On the sample plot, area 1.0 ha, the number of individual grown-up beech, fir and spruce trees is 674, and their mixture proportion is 68.1%:18.1%:13.8%. Beech dominates in the category of grown-up young plants which is caused by its "social matching".

Beech trees, after the age of 10 years, with the increasing age rapidly increase crown diameter and, at the same age, beech trees are higher than fir trees on average for about 10 cm.

There is a statistically significant difference in total abundance of young plants between the areas with low stoniness and high percentage of ground flora, and the areas with intensive surface stoniness.

A statistically significant difference was determined in the regeneration abundance depending on the effect of micro-habitat exposure, i.e. between the SE and N exposures. The regeneration abundance in micro-habitats with SE exposure is two times higher than in those with N exposure.

The dominance of beech in the lower, underwood layer is caused by the process of "beeching", while fir seedlings are abundant in the regeneration category.

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DIVERSITY OF TREES IN THE STANDS OF BEECH AND VALUABLE BROADLEAVES IN THE AREA OF N.P. “ĐERDAP“

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Abstract: *Modern approach to planning in forestry and environmental protection requires the acquisition of a series of actual and real information on stand diversity. This is especially significant in the highly structured forests rich in tree species of different dimensions. The diversity in the ecologically and economically very valuable stands of beech and valuable broadleaves of N.P. “Đerdap“ was analysed and numerically defined from the aspect of diversity of dimensions and tree numbers. The diversity was defined by the so-called dimension differentiation of trees and Shannon diversity index. The study parameters enable a detailed and a good-quality description of the actual stand state, as well as the potential quantification of the possible reduction of the biotic diversity and ecological stability at the stand level.*

Key words: stand, beech, valuable broadleaves, diversity of species and dimensions

1. INTRODUCTION

From the very beginning of the planned forest management, its objective was the sustainable management. The first and so far the oldest written report on “sustainability in forestry” dates back to Von Carlowitz in 1713 (SCH ANZ 1996). The principle of sustainability and the methods of sustainable forest management were further developed by Hartig and Cotta, although at that time the sustainability in forestry was primarily understood as the sustainability of wood production.

The introduction of multifunctional forestry became increasingly intensive at the beginning of the second half of the 20th century, when numerous protection and social functions were placed at least at the same level with production functions. Forests were understood as the places in which man can live and recreate and as the places which contribute to the protection of climate, water and soil. From the modern aspect, functional diversity of forests is clearly identified by MCPFE Declaration and Resolution (2000) and it includes the production of wood and nonwood forest products, protection of forest resources, conservation and vitality of forest ecosystems, biological diversity and the protection and social functions.

It should be emphasised that today the sustainability of biodiversity is becoming an imperative, as in the past it was the sustainability of wood production. In the last years, increasing attention has been devoted to the research and analyses of biodiversity in forestry (PRETZSCH 2002).

2. STUDY AREA AND METHOD

The research was performed in the N.P. “Đerdap”, in the compartment 64, M.U. “Štrbačko Korito”. The study stands sized 0.35 ha are in the forest of beech and valuable broadleaves, with

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a significant presence of Turkish hazel, an exceptionally rare species in our forests. Along with Turkish hazel, other species of valuable broadleaves (Norway maple, wild cherry, sycamore, wild service tree, elm, lime), are present, as well as hornbeam and flowering ash.

In the initial phase of the study, the instruments were controlled and the data sources were located. The classical sources of data in such investigations are sample plots, so two sample plots (A and B) were singled out on which the diameters of all trees were measured at the height of 1.30 m, the heights were measured on a determined sample of trees and the tree species of individual trees were identified.

The diversity of woody species in the study stands was analysed depending on the number of individuals and the relative share of basal area of the present species compared to the total basal area of the stand. In this aim, we applied Shannon-index, which is calculated by the following formula:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i = -\sum_{i=1}^{S}\left[\frac{n_i}{n}\ln\frac{n_i}{n}\right]$$

, where: S = number of identified tree species, n_i = number of individuals belonging to i-th species or the basal area and volume of i-th species, n = total number of all individuals or total basal area, i.e. stand volume, $p_i = n_i/n$. Therefore, the diversity of woody species in the study stands was analysed depending on the number of individuals and the relative share of basal area and volume of the present species compared to the total basal area and volume of the stand.

The diversity of tree dimensions was calculated by the so-called dimension differentiation, i.e. structural index after FÜLDNER (1995):

$$T_d = 1 - \frac{D_t}{D_d}$$

In which: D_t – diameter at breast height of the thinner immediate neighbour, D_d – diameter at breast height of the larger nearest neighbour.

The average diameter differentiation was based on the differentiation of the dimensions of two nearest neighbours (the reference tree and its nearest neighbour) for all woody species together:

$$T_{di} = \frac{1}{n}\sum_{i=1}^{n}(1 - r_i)$$

Where r_i equals $\frac{D_t}{D_d}$. In this aim, the nearest neighbour was identified and measured for about 50% of the randomly selected trees (based on the Tables of random numbers).

3. PROBLEM AND OBJECTIVE

As the stand structure strongly affects the level of stand increment and production (PRETZSCH 1993, 1997), and as the increase of the vertical and horizontal structure of the stand regularly increases the diversity of plant and animal life and their interrelationship, which contributes to ecological stability (ALTENKIRCH 1982, HABER 1982), the detailed stand structure description and quantifying has a special place in forestry and ecological research.

Stand structure can be described by the parameters which enable the comparison between a given situation and one or more standard situations (GADOW 2002). In this, the parameters which describe the horizontal or vertical structures differ, i.e. simple or spatial stand structure

(WENK *et al.* 1990, KOTAR 1993, PRETZSCH 1996, GADOW 2002; STAJIĆ, VUČKOVIĆ 2005, 2006...). A high number of parameters, which describe the stand structure and diversity can be grouped and compared, whether their determination requires detailed measurement of the coordinates of trees in the space or not. Also, the different indices of structure and diversity can be grouped, whether the given indices characterise the structure and diversity at the level of the entire stand, or the so-called "small area" structure and diversity in the immediate and direct vicinity of the observed (central) trees.

In the commercial forests, but also in the conserved forests of virgin character, biodiversity is the key element for the assessment of forest stability (KIMMINS 1987). The parameters of structure, in addition to being important elements for the assessment of stand structure, are also very suitable for the estimation, monitoring and comparison of the biotic diversity (diversity of tree positions, tree dimensions, woody species, dominance) and thus also for the characterisation of the level of ecological stability of forest ecosystems. Accordingly, the level of total forest diversity has a very significant ecological, but also an economic dimension, therefore its accurate assessment represents an equally necessary base, both for forest management of special purpose forests, and for the forests with predominant economic function (STAJIĆ, VUČKOVIĆ 2005).

The methodology of diversity measurement depends on the available time, costs and the desired precision of diversity quantification and it varies depending on the goal. From the aspect of rational management, the structure of forest ecosystems can be rather well described by the analysis of the spatial mingling of species, variations of tree dimensions, and by the spatial distribution of trees, with the simultaneous characterising of both the stand diversity and the stand structure (GADOW, HUI 1998).

Detailed studies of spatial stand structure are particularly significant for highly structured forests, rich in woody species of various dimensions, such as the mixed and all-aged forests of beech and different valuable broadleaves in the M.U. "Štrbačko Korito" in N.P."Đerdap". According to DRACHENFELS *et al.* (1984), mixed forests of beech and valuable broadleaves are classified as the European forest communities which are the richest in woody species. For this reason, and bearing in mind the above facts, the aim of this study is to analyse the spatial structure in a mixed all-aged forest of beech and valuable broadleaves, and to quantify numerically the two important aspects of biodiversity – the diversity of woody species and the diversity of tree dimensions of the present woody species.

4. RESULTS

The term *diversity* is applicable to any abstract and concrete system, which can be classified into individual elements and their lower units (NAGEL 1976).

Diversity consists of two components (PIELOU 1977, LUDWIG, REYNOLDS 1988):

1. species abundance, or *species richness* - the number of species in a community

2. evenness – the number of individuals per individual species in the community.

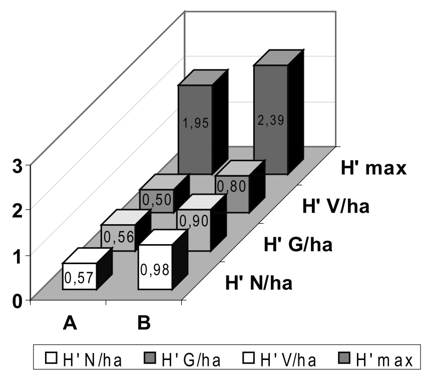
Numerous indices of diversity (PIELOU 1977, LUDWIG, REYNOLDS 1988, MAGURRAN 1988...) have been designed for the quantification of diversity. The best known and most often applied diversity index is Shannon index (SHANNON, WEAVER 1949), which originates from the information theory, because in fact it represents a measure of the average degree of indefiniteness - entropy. In forestry, it is applied in numerous modern studies for the characterisation of the diversity and stand structure (GADOW 1999, PRETZSCH 1996; FÜLDNER 1995, KÖHL, ZINGG 1995, NEUMANN, STARLINGER 2001...).

The diversity level in the study stands was first characterised from the aspect of richness of woody species. In his aim, Shannon diversity index was calculated based on the relative percentage of individual tree species in the total number of trees, basal area and stand volume (Table 1, Figure 1). For the diversity quantification, in addition to the relative percentage of individual tree species in the total number of trees, it is suitable to calculate the diversity based on the size of basal area or volume, because such methods also calculate the true dimensions of the trees, by which their effect on the regeneration and ground flora (STAJIĆ, VUČKOVIĆ 2005) is explained.

Table 1. Relative parts of tree species in total tree number, basal area and volume

	Stand A			Stand B		
	Relative parts					
	No. of trees	Basal area	Volume	No. of trees	Basal area	Volume
Fagus moesiaca	0.872	0.872	0.884	0.737	0.775	0.803
Corylus colurna	0.060	0.054	0.050	0.060	0.080	0.071
Acer platanoides	0.037	0.040	0.036	0.049	0.053	0.049
Acer pseudoplatanus	0.014	0.014	0.013	0.003	0.003	0.003
Fraxinus ornus	0.009	0.002	0.002	0.115	0.047	0.035
Prunus avium	0.005	0.015	0.013	0.008	0.027	0.025
Carpinus betulus	0.003	0.003	0.002	0.003	0.001	0.001
Fraxinus excelsior				0.005	0.005	0.005
Tilia grandifolia				0.003	0.003	0.002
Ulmus montana				0.003	0.002	0.002
Sorbus torminalis				0.014	0.004	0.004

Figure 1. Current (H') and potential (H'_{max}) Schannon index



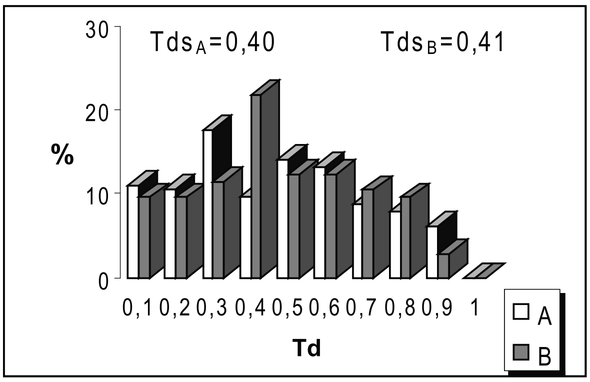
The study results show that species diversity, calculated based on the share of woody species in the total number of trees, is almost twice higher in stand B, than in stand A (Figure 1), which is primarily due to a higher number and a somewhat more uniform share of species in the overall number of trees in stand B, compared to stand A (Table 1).

Also, species diversity compared to the share per tree number in both stands is higher than species diversity compared to the relative share per basal area and volume. Accordingly, it can be concluded that the percentage of individual tree species (beech, wild cherry, Norway maple) in the total stand basal area and volume is even more significant than in the total number of trees. Thus e.g. 74% of beech trees in stand B make almost 78% of the total basal area and 80% of the volume (Table 1).

A more detailed definition of stand structure and diversity, in addition to the quantification of richness or woody species, is achieved by the analysis of differences of the dimensions of trees and their nearest neighbours. The simplest information on the differences of basic elements of tree growth in forest stands are obtained by the analysis of the distribution of trees per diameter and height degrees. However, the information potential of this analysis is limited, because it is impossible to quantify the differences in spatial dimensions of the nearest neighbours and to assess precisely the dimensions of the neighbouring trees, i.e. whether the dimensions of the neighbouring trees are smaller or larger, which would give the basic information on the competition at the level of individual trees and stands.

The dimensional differentiation of trees after FÜLDNER (1995) characterises quantitatively the dimensional differences of nearest neighbour trees. The differentiation of tree diameter (T_d) describes the ratio between the observed (reference) tree and its nearest neighbour tree and it is defined as the quotient of the smaller and the larger trees, subtracted from 1. If T_d=0 it means that the trees have equal diameters, and the higher the differences of diameters of the observed trees, the greater the sizes of T_d. The result T_d=1 is practically hypothetical, because it assumes the diameters of infinitely large and small trees.

Figure 2. Diameter differentiation for the stands A and B



The average values of diameter differentiation in the study stands (Tds_A and Tds_B) were calculated as arithmetic mean of T_d for each analysed tree (Figure 2). The results lead to a conclusion that diameter differentiation in the study stands is practically equal and amounts to about 0.40 (Figure 2). This means that, on the average, the ratio between a randomly selected tree and its nearest-neighbour tree is as follows: the diameter of the smaller tree accounts for about 60% of the diameter of the larger tree.

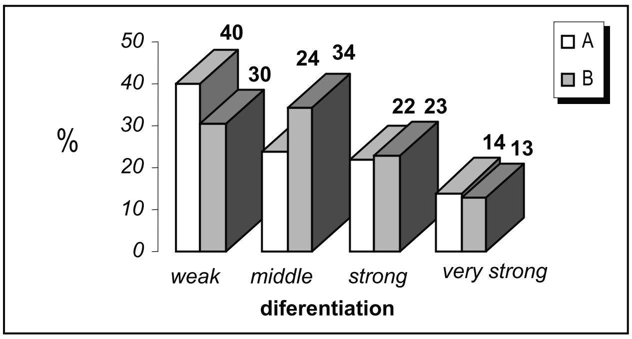
As the same average Tds can be obtained from a highly different structure of the data on T_d (higher or lower dispersion of data), in the aim of the clearest possible idea of the true stand structure and diversity, the assessed Td values were classified per 0.1-degrees (Figure 2). The greatest differences of the values of dimensional differentiation of the two study stands were calculated for the average value, but it is also evident that between them there are no great differences in diameter differentiation.

An even more reliable idea on the structure and dimensional diversity of these stands is obtained by the classification of individual sizes of T_d according to the differentiation intensity in following class (FÜLDNER 1995):

- poor differentiation (Td = 0-0.3)
- medium differentiation (Td = 0.3-0.5)
- high differentiation (Td = 0.5-0.7)
- very high differentiation (Td = 0.7-1.0)

The percentages of individual Tds per the above classes for stands A and B are presented in Figure 3. The analysis of data shows that approximately 2/3 of all data are within the classes "poor

Figure 3. Individual values of diameter differentiation per differentiation classes for the stands A and B.



differentiation" and "medium differentiation", which means that only 1/3 of the trees in these stands has nearest neighbours with averagely high or very high dimensional differences, while the greatest number of trees (about 2/3) have similar dimensions as the nearest-neighbour tree.

The defined classes and the distribution of Td values within the classes are also good indicators of the intensity of the stand structure and the level of competition between the trees. Namely, if the trees in the most general sense are divided into two biological positions (I – dominant trees in the upper layer, II – suppressed trees in the lower layer), based on the results it can be concluded that in the study stands the nearest neighbours of about 35% of trees belong to the same biological position as the reference tree, while the nearest neighbours of about 30% of trees probably in most cases belong to the same biological position. Taking this into account, the rational conclusion is that about 2/3 trees have high or very high competition of nearest neighbour trees. On the other hand, somewhat more than 1/3 of trees have poor and very poor competition from the nearest neighbours, which mostly do not belong to the same biological position.

5. CONCLUSIONS

Mixed and all-aged, highly structured economic and natural forests are characterised by the richness of species and dimensions and by their spatial mingling, so their ecological significance is high. The first step in the description of the true state of such complex systems is a detailed structural determination. This study presents the potential application of some parameters which enable a better description of the stand horizontal and spatial structure than the conventional parameters of structure, i.e. the share of tree species in the total number of trees, or the distribution of tree frequency per diameters.

Taking into account the high positive correlation between the level of forest stand structure and the level of diversity, modern analysis of stand structure contributes to the more precise and comprehensive estimation of the diversity in forest stands. One of the levels for the analysis and evaluation of stand structure and diversity is the species diversity. In forestry, in addition to the assessment of diversity based on the share of present woody species, the diversity is also estimated based on the basal area and volume, in the aim of better estimation of the present state and the forecast of forest and forest ecosystem development.

Spatial distribution of tree dimensions is an important parameter for the characterisation of the intensity of stand structure. The basic idea on the dimensional differences among the trees can be estimated based on the curve which represents the number of trees per individual diameter degrees. However, the stands of identical diameter structure can differ considerably because the trees of different diameters can be spatially more or less mingled. The dimensional diversity of the trees in the study stands was quantified by FÜLDNER's structural index.

The majority of countries with developed forestry tend to increase the level of forest structure, all-aged and mixed forests. The decision making at different levels of forest policy and management planning requires the information on the current true state of forests and forest ecosystems and the biodiversity level in them. In the commercial forests, as well as in the conserved ecosystems, the characteristics of structure and biodiversity are the key elements for the assessment of forest function, stability and hazards, so forest management and administration by the principles of sustainable development require permanent monitoring of different aspects of diversity.

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BIOLOGICAL POSITION AND TREE QUALITY IN HIGH BEECH STANDS IN THE AREA OF SEVERNI KUČAJ

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Abstract: *The effect of biological position and tree quality on the stand productive characteristics was researched in three beech stands, in Management Units "Majdan-Kučajna" and "Crni Vrh", in the area of Severni Kučaj in East Serbia. The biological position, stem quality and crown quality were classified by the method of the Faculty of Forestry in Belgrade. The study areas were two stands of montane beech forest - Fagetum moesiace montanum (stand 42a - III site class and 42b - III/IV site class), and one stand of submontane beech forest - Fagetum moesiace submontanum (stand 33a - II site class). The distribution of tree number, basal area, volume and volume increment per biological position, stem quality and crown quality was presented and analysed. Based on the in-depth research, it was concluded that not only the productivity, but also the quality of the study stands, decrease with the lowering of the site class. It was also concluded that the stands of the best site class have the most favourable distribution of taxation elements per quality classes.*

Key words: beech, stand quality, site class, productivity.

1. INTRODUCTION

Beech is the most widespread species of forest trees in Serbia. Total area of pure beech forests in Serbia is 647,821 ha or 28%. Mixed forests of beech, oaks and other broadleaves, as well as beech and conifers, occupy the area of 379,302 ha or 16.4%. Wood volume of pure beech forests is 91,841.305 m3 or 39.1 %, and mixed forests with other broadleaves additional 38,708.593 m3 or 16.5 %, which is altogether 55.6 % (Stojanović, Krstić, 2000).

In Severni Kučaj area, an explicitly broadleaf area, the most represented tree species is also beech. Its percentage in the total forested area is 70%, in total volume 76.2%, and in volume increment 67.8% (Medarević *et al.*, 2003). Because of the previous management method, these forests are mainly all-aged, and their structure and quality is heterogeneous. To define the silvicultural aims and to be able to implement the adequate silvicultural measures, forest quality is a very important factor, in addition to production characteristics.

The tree biological position and quality, by the method presented in this paper, was researched in three stands of different ecological conditions, in the area of Severni Kučaj, within the project "Method of assessment of quality and assortment structure of beech high stands in Serbia".

2. STUDY AREA AND METHOD

Two study areas with three stands were established in the forest area "Severni Kučaj", in Management Units "Majdan-Kučajna" and "Crni Vrh".

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The first stand is in MU "Majdan-Kučajna", compartment 33a, in the submontane beech forest *Fagetum moesiace submontanum*, at the average altitude of 446 m (406-513 m), slope 20.6° (7°-28.0°) and exposure West-Northwest.

The second study area is in MU " Crni Vrh", and it includes two stands. One stand is in compartment 42a, in montane beech forest *Fagetum moesiace montanum.* Its average altitude is 956 m (929-982 m), slope 10.8° (6°-17.0°), and exposure Northwest. The other stand is in compartment 42b, also in montane beech forest *Fagetum moesiace montanum*, where the average altitude is 1000.2 m (984-1020 m), slope 11.1° (7°-15°), exposure Northwest.

The study method is based on the "Method of taxation data collection and processing for the study of quality and assortment structure of beech high stands in Serbia" by Koprivica *et al.* (2006). The general stand and site data are collected on sample plots designed in the form of circles, size 500 m2 (radius 12.62 m), distributed in the square grid network, spacing 100 m, so that one circle represents 1 ha of the study stand. In this way, sample plots cover 5% of the study area. The first stand includes 23 sample plots, the second stand – 17, and in the third stand - 10 sample plots.

3. RESULTS

3.1. Soil conditions

The stand in MU "Majdan-Kučajna" is characterised by very different conditions for beech growth and development. The bedrock consists of limestones, red sandstones and quartz sandstones.

The black earths and the illimerised soils (luvisols) occur on limestone bedrocks and acid brown soils occur on siliceous bedrocks. The illimerised soils (luvisols) occur in the flattened parts of the stand on limestone bedrocks Black soils are developed in the stand parts on limestones, on steep slopes. Brown limestone soils are only fragmentarily represented in individual parts of the stand, but outside the study sample plots. Acid brown soils are formed in the stand part over red and quartz sandstones. Colluvial black soils are formed by the effects of different parent rocks on soil properties, i.e. by colluvial diluvial processes at individual places on limestone. Although they are on the limestone bedrock, they contain also the material of siliceous origin in the solum, which is brought from the higher elevations with sandstone bedrock.

Soil conditions in MU "Crni Vrh", in both study stands, are far more uniform. In both study stands, the soil is colluvial dystric ranker. In the lower part of the profile, and particularly in the stand 42b, there are signs of brownisation (Čokeša *et al.* 2006).

3.2. Production characteristics of the study stands

Production characteristics of the study stands are represented by the basic taxation data (Table 2), reported by Koprivica *et al.* (2006). All three stands are group-selection all-aged stands. In individual groups which are in the mature stage, spontaneous regeneration started depending on the canopy and weediness.

The number of trees per circles varies depending on the development phases of individual tree groups and the scope of previous felling. However, it ranges mainly within the limits of the optimal values. In addition to the above, the number of trees also depends on the site class. The stand of the best site class (33a) has the lowest number of trees (274 trees per ha). In other two stands, the number of trees is equal, 321 per ha in stand 42a, and 308 per ha in stand 42b. The number of trees in stand 42b, regardless of the site class, is somewhat lower because of the higher effect of unfavourable abiotic factors (snow, ice and wind).

Basal area and volume, as the direct indicators of productivity are also conditioned by site class, so their values are the highest in the best site class, and they decrease with the lowering of the site class. Volume in the stand of the best site class - 33a is 522.5 m³/ha, it is 379.6 m³/ha in the stand of the second site class - 42a, and the lowest volume 333.2 m3/ha was measured in the stand 42b. It should be emphasised that the timber supply values in the study stands are higher than the average value in Serbia, which in high beech forests amounts to 207.2 m3/ha (Tomanić 1993) and the optimal estimated volume for beech (250.0 m3/ha) (Milin *et al.*, 1994).

Table 1: Taxation elements in the study stand

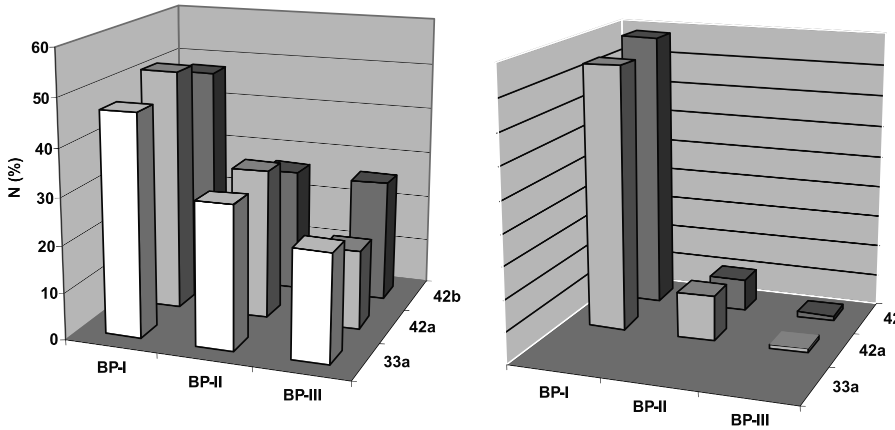
Management Unit	Stand	Site class	Taxation elements			
			Number of trees (trees/ha)	Basal area (m2/ha)	Volume (m3/ha)	Volume increment (m3/ha)
MU "Majdan-Kučajna"	33a	II	274	33.4	522.5	8.60
MU "Crni Vrh"	42a	III	321	31.7	379.6	6.61
MU "Crni Vrh"	42b	III/IV	308	31.5	333.2	4.96

Current volume increment, as the taxation element which shows stand productivity, is also directly conditioned by site quality. The stand on the best site class (33a) has current volume increment 8.6 m³/ha. The increment of the stand of the poorer site class (42a) is 6.61 m³/ha. The increment in the stand of the lowest site class, which is affected by the extreme abiotic factors, with very frequent windbreaks and other damage, is 4.96 m3/ha. Average value of current increment for Serbia in high beech forests is 4.6 m3/ha (Tomanić, 1993). The optimal value of current increment is 6.0 m3/ha (Milin, *et al.*, 1994).

3.3 Distribution of productivity taxation elements per biological position

Diagram 1a shows that in all three study stands, the first biological position has the greatest number of trees (about 50%) and that the decrease of the number of trees in the lower biological positions is relatively moderate and gradual. This indicates, inter alia, that it is an all-aged stand. The number of trees in the second biological position is about 30% in the stands 33a and 42a, and somewhat lower in the stand 42b - 26%. The trees of the third biological position are the most numerous in the stand 42b (26%), somewhat less in stand 33a - 23%, and in the stand 42a, their number is 17%.

Diagram 1: Tree number (a) and wood volume (b) per biological position



The decrease of volume (Diagram 1b) and volume increment with the biological position is not as moderate and gradual as the decrease of the number of trees. This indicates that the bearers of productivity are almost exclusively the trees of the first biological position. Therefore, the trees with the best stem and crown quality should primarily be searched among such trees, and they should be paid attention to by silvicultural measures.

However, these are group-selection all-aged three-layer stands in which the number of dominant trees in the absolute amount is not sufficient, so special attention should be given to the second and the third biological positions, which are very important constitutive layers in such stand structure.

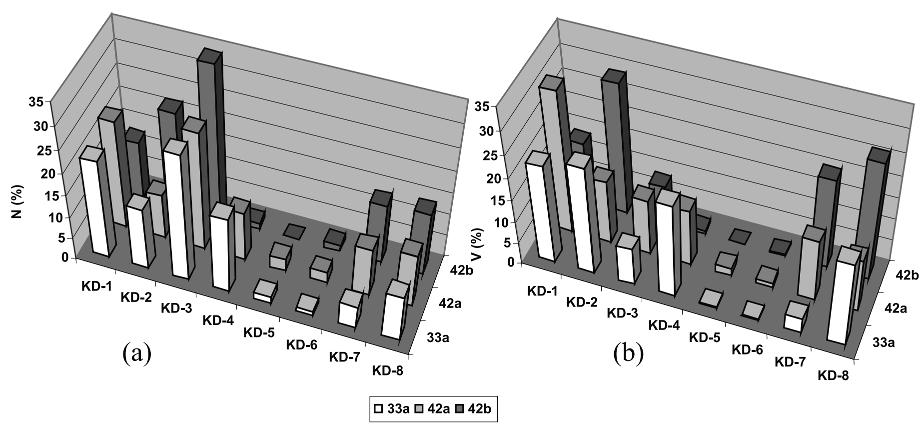
It should be noted that in the stands (particularly in 33a) among the dominant trees, there is a smaller number of predominant trees, whose removal should precede all other silvicultural works. Their further staying in the stand could lead to a significant drop of their quality and health state, which would cause the loss of the total yield and assortment structure. Also, each later felling of the predominant trees would cause great damage to the regeneration during their felling and extraction.

3.4. Distribution of productivity taxation elements per stem quality

Diagram 2 shows that in the stands of better site classes and productivity (33a and 42a), most of the trees are concentrated in the first four stem qualities and a smaller share is in the two lowest stem qualities. In the stand of the poorest site class and production characteristics (42b), the trees are concentrated in the first three and in the two lowest stem qualities. As it has already been noted, stand 33a has a number of predominant trees, whose stems are branched, so the stand has a greater percentage of KD-2 trees on the account of KD-1 trees. Consequently, this stand, although its site class and production characteristics are better than those of the stand 42a, has fewer trees of the best stem quality (Diagrams 2a and 2b). In all three stands, and particularly in stand 42b, which is a poorer site class and productivity, the percentage of curved trees is as high as 34% (KD-3). However, as these are mainly thinner trees which are predominantly in the third biological position, in contrast to their percentage in tree number, their share in volume (about 9%) and volume increment (13%) is low.

The number of mechanically damaged and decayed trees (KD-7 and KD-8) rises with the decrease of site class and stand productivity. This is particularly high in the stand 42b, which is influenced by unfavourable climate factors. In many cases, broken branches and even entire

Diagram 2: The number of trees (a) and wood volume (b) per stem quality

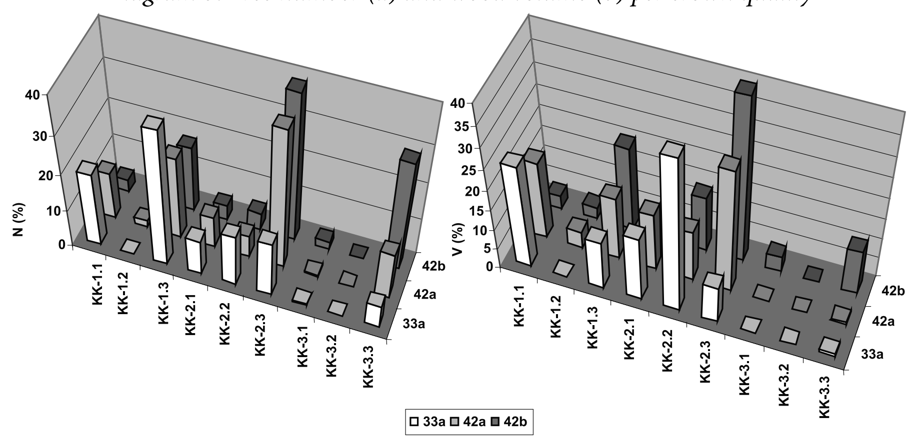


trees are caused by the impact of snow, ice and wind. The breaking is often caused by the infection of different pathogens (Marković *et al.*, 2006), and there are many partly decayed or decayed trees (KD-8). Due to the adverse effects of abiotic factors, on many places in the stand 42b the canopy is broken, which resulted in the higher percentage of branched trees (KD-2). The sizes of the damaged and decayed trees are often large, so that their percentage in volume and volume increment is significant. The higher percentage of branched trees (KD-2) and partly decayed and decayed trees in the volume, than in the number of trees in stand 33a, is caused by the presence of predominant trees.

3.5 Distribution of production taxation elements per crown quality

Diagrams 3a and 3b show that the values of stand productivity characteristics and crown quality decrease with the lower site class. The highest percentage of trees with better-quality crowns (from KK-1.1 to KK-2.2) occurs in the stand 33a, and the lowest in stand 42b. Quite the reverse, the poorer crowns (from KK-2.3 to KK-3.3) are most represented in stand 42b, and least represented in stand 33a. This is clearly visible in Diagram 3. In all three stands there is a high percentage of trees with flattened, asymmetric and deformed crowns (KK-1.3, KK-2.3 and KK-3.3), which points to the failures in the previous stand tending.

Diagram 3: Tree number (a) and wood volume (b) per crown quality



The distribution of volume per crown quality is proportional to the distribution of tree number. As in the stand of the best site class (33a) only the thinnest trees have flattened, asymmetric and deformed crowns (KK-1.3, KK-2.3 and KK-3.3), these trees have low shares in the stand volume. In the stands of the poorer site classes (particularly stand 42b) such crowns occur on larger trees, so their percentage in the present stand productivity is very significant. The percentage of such crowns in stand 33a is 56%, in stand 42a - 71%, while in stand 42b, the percentage of such crowns is as much as 85%. The crowns of larger trees in stand 42b are deformed because of the higher effect of extreme climate conditions. The higher percentage of the trees with crowns KK-2.2 (which are as a rule too large) in the volume in stand 33a is the result of the presence of predominant trees in the stand.

The distribution of current volume increment is similar to that of the volume distribution, but the larger trees with poor and deformed crowns (KK-1.3) in the stand of the poorest site class (42b) are stagnating in increment compared to thinner trees of the same crown quality in the other two stands. The lower increment of the larger trees is caused by the insufficient assimilation apparatus on these trees, due to intensive crown damage caused by wind, snow and ice, which is very frequent in the conditions of Crni Vrh.

4. CONCLUSIONS

Based on the research of the effect of biological position and tree quality on the stand production characteristics on different site classes, we can conclude as follows:

- The productivity and quality characteristics of the stand decrease with the decrease of site class;
- The better structure of biological and quality classes correspond to the higher values of taxation elements;
- The all-aged high beech stands in the study area are three-layered, which indicates that there are three generations of trees, of which the most numerous is the first generation and the least numerous is the third generation. The decrease of the number of trees between them is moderate and gradual;
- The absolute bearers of productivity are the trees of the first biological position. By silvicultural measures, the increment value should be concentrated to the trees with the best stem and crown quality;
- The branched predominant trees with oversized crowns should be removed before each planned silvicultural treatment in the stand;
- The percentage of the trees of poorer stem phenotype characteristics is higher per tree number than per volume and volume increment. Exceptions are mechanically damaged, partly decayed and decayed trees, which are larger and their percentage increases with the poorer site classes and with exposure to extreme climate conditions;
- The percentage of trees with good-quality crowns, as well as the stand productivity, decreases with the decrease of site class. The productivity drops when the percentage of the trees with poor crowns rises. Due to inadequate tending in all study stands, there is a high percentage of trees with deformed and assymetric crowns, which also rises with the decrease of site class. The smallest crowns in the stand of the best site class are on the thinnest trees, while in the stands of the lowest site class very often large trees have small crowns, which means the insufficient assimilation apparatus for the production of increment. In this crown class (KK-1.3) current volume increment is equal in all three stands. Small crowns on larger trees are the consequence of the higher effect of unfavourable climate factors in stand 42b, Management Unit "Crni Vrh";
- Regarding the silvicultural goals and measures, these stands should be treated as group-selection all-aged stands; their quality and productivity depends on the site class and on the mechanical effects of the extreme climate factors.

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EFFECTS OF SELECTION AND LINEAR-SELECTION THINNING ON TIMBER ASSORTMENT STRUCTURE OF THE GROWING STOCK IN YOUNG SCOTS PINE (*PINUS SILVESTRIS* L.) PLANTATION

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Abstract: *Effects of variants of thinning on the timber assortment structure of the growing stock were studied in sample plots in Scots pine plantation in the region of Godech Forest Service, Sofia district. The plantation was established in 1956 with the initial density of 8000-9000 nurslings per hectare. In 1973, five variants of thinning were carried out in the sample plots: selection free thinning, as well as four variants of linear-selection thinning with cutting out every 3rd, 4th, 5th or 6th row, respectively. Selections thinning with low to medium intensity were implemented in 1983 and 1993.*

In 2003 higher quantities of large and medium sized merchantable timber were still continuously being produced by large clear-bole trees along the one-time corridors cut across the stands - results achieved in spite of the evening-out effect on the average growing space for the trees in the plots, produced through consecutive selection thinnings. Data for the quantities of large and medium sized merchantable timber (in percentages from the total timber volume) in the sample plots in 1983, 1993 and 2003 were used to represent the long term dynamics of the assortment structure of the growing stocks.

Key words: *Pinus silvestris L., plantations, thinning, timber assortment structure*

1. INTRODUCTION

In the past decades Scots pine plantations have been established in vast areas in Bulgaria on former barren land or on sites that underwent conversion of the main species. In pursuance of the permanent task of appropriate and timely tending such stands have been predominantly treated with successive applications of selective thinning, but innovative techniques of linear and linear-selection methods of thinning have been also experimented and introduced in the forestry practice.

The effects of different types of thinning on the timber assortment structure of the growing stock in young Scots pine plantations have been so far assessed and compared in Bulgaria on the basis of data obtained by relevant observations made not more than 20 years after first thinning. Sources of such information were the sample plots established in 1973 in Scots pine plantation in the region of Godech Forest Service, Sofia region. Key attributes of the growing stock in the plots, their timber assortment constitution including, were measured and assessed in 1973, 1983 and 1993 and analytically compared (Garelkov, 1983; Stiptsov et al., 1993, 1995). Analogous findings from longer lasting native experiments are lacking, so results from recent further inventories in the Godech plots are of special interest.

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2. OBJECT AND METHODS

Last survey of the sample plots in the region of Godech Forest Service was made in 2003, aimed at further tracing the multiple changes in the experimental growing stocks and in their timber assortment structure in particular.

The Scots pine plantation was established in 1956 on a site of middle quality at an altitude of about 800 m, with the initial density of 8000-9000 nurslings per hectare. In 1973, five variants of thinning were carried out (in two iterations) in 10 sample plots x 0.2 ha: free thinning, as well as four variants of row-selection thinning with cutting out every 3rd, 4th, 5th or 6th row. Control sample plots were also established. Subsequent selective thinnings with low to moderate intensity were carried out in the plots in 1983 and 1993 (Table 1).

Table 1. Thinning intensity regime in the sample plots in 1973, 1983 and 1993

Variant of first thinning	Thinning degrees, Vc in % from V before treatment[2]			Summarized thinning intensities	
	Years of thinning entries:				
	1973	1983	1993	1973+1983	1973+1983+1993
Free thinning	22,8	7,3	20,4	30,1	50,5
Linear-selection thinning with cutting out:					
every 3rd row	37,4	13,3	9,2	50,7	59,9
every 4th row	33,3	21,2	15,6	54,5	70,1
every 5th row	26,8	13,9	22,1	40,7	62,8
every 6th row	22,1	3,7	22,8	25,8	48,6

In 2003 d.b.h. of all trees and heights of sufficient number of trees were measured and stem quality of the trees was assessed in order to determine the effects of the series of thinning on the formation of different timber assortments in the plots. Local timber categories table for Scots pine plantations in Bulgaria (Krastanov, Belyakov and Shikov, 1983) was used to determine the volume of wood (in m^3/ha) available in the sample plots, assigned to large, medium and small-sized merchantable timber[3] and firewood categories. For experimental plots where linear-selection first thinnings have been carried out data were separately processed and summarized for trees growing along one-time cut-out corridors and for trees inside the tree strips formed through row removals. The quantities of large and medium-sized timber in the plots in 1983, 1993 and 2003 were compared to define the long-term dynamics of the most valuable timber categories in the growing stocks.

3. RESULTS AND DISCUSSION

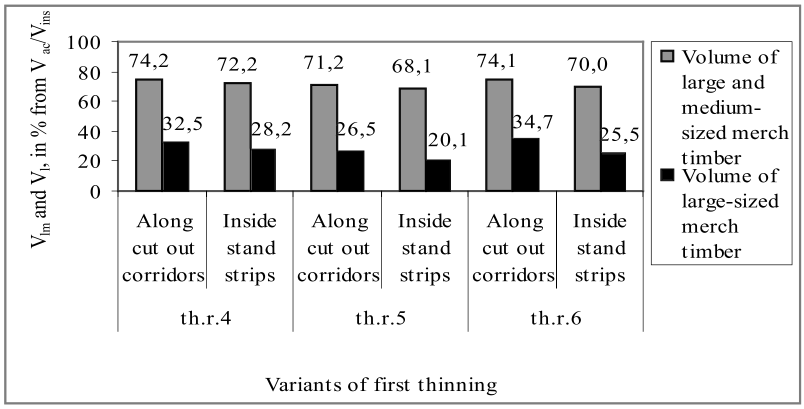
The theoretically definable shares of the number of peripheral trees bordering cut-out rows and of trees from inner rows in the coulisses, for thinning scheme with cutting-out every 4th row are 67% and 33%; with cutting-out every 5th row – 50% and 50% and with cutting-out every 6th row – 40% and 60% respectively. The real values of the share of peripheral and inner trees in 2003 were tending towards these given above, being 68,4% - 31,6%; 52,5% - 47,5% and 37,4% - 62,6%,

2 Abbreviations used in the text, tables and figures: V - total timber volume (m3/ha); Vc – cut timber volume; Vlm – volume of large and medium-sized merchantable (=merch) timber; Vl – volume of large-sized merch timber; d.b.h. – diameter at breast height, Dtop - diameter at top end of a round wood assortment; s.p. - sample plot; c.s.p. - control s.p.; f. th. - free thinning; th.r.3 (4, 5 or 6) - thinning with cutting out every 3-rd, 4-th, 5-th or 6-th row; Vac – volume of the trees growing along corridors; Vins – volume of the trees from inner rows of the stand strips.

3 Categories of merchantable timber acc. Bulgarian standard: large-sized timber – (logs or assortments with) D_{top} ≥ 18 cm; medium-sized timber – D_{top} 8-17 cm; small-sized timber – D_{top} 3-7 cm.

respectively, i.e. in this respect stand structures established by named first treatments were not considerably changed by subsequent two selection thinnings.

Figure 1. Volume of large and medium (Vlm) and of only large (Vl) merchantable timber (in 2003) for trees bordering cut-out rows and for trees in inner rows of the tree strips in plots treated with linear-selection first thinning



The data presented at Fig. 1 show that in stands first thinned with cutting out every forth, fifth or sixth row the quantities of medium and large merchantable timber in trees positioned along corridors are with 2.0%, 3.1% and 4.1% respectively, higher than these in trees from inner rows in the coulisses, and the shares of large timber alone are with 4.3%, 6.4% and 9.1% higher. A trend is noticeable towards increase of these exceeding values with decreasing of the number of cut-out rows. It is due to the fact that the more rarely spaced are the cut-out rows, the greater is the quantity of trees belonging to inner rows of the tree coulisses.

Changes in the individual and average growing space for the trees in the plots depend on the dynamics of self-thinning processes as well as on the types and degrees of consecutive thinning. Some 33%, 25%, 20% or 17% of the volume in the plots treated with linear-selection first thinning were removed by cutting out entire rows. Higher values of real intensities of thinning applied in 1973 (Table 1) imply removals of another approximately 4-8% of the respective total standing volumes in the plots, spent most of all for negative selection. Higher degrees of positive selection were possible only in the plots treated with free thinning.

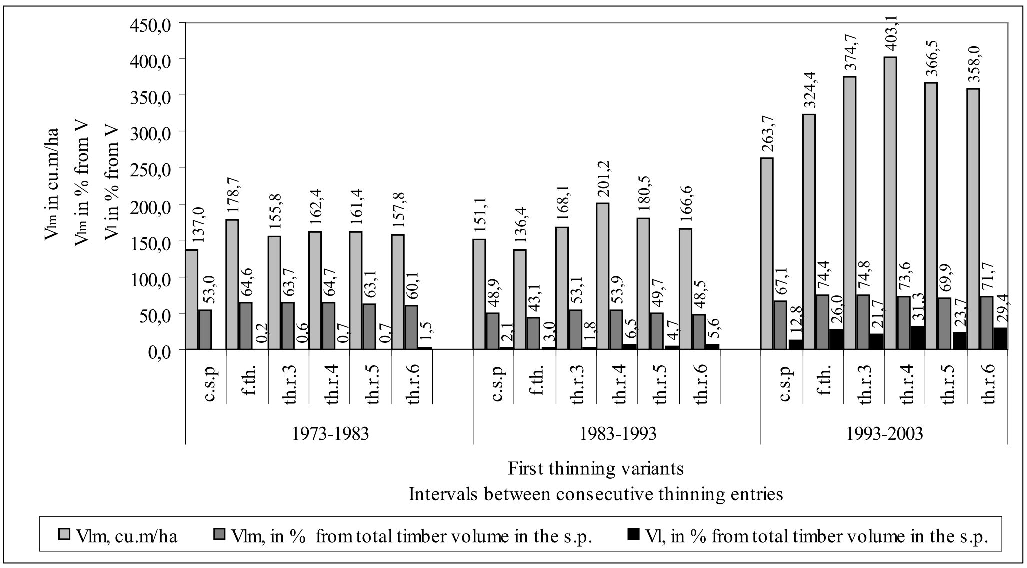
Table 2. Number of trees (N) and volume of stem timber in the sample plots at the end of thinning intervals

Variants of thinning in the sample plots	Last years of thinning intervals:					
	1983		1993		2003	
	Growing stock characteristics:					
	N ths/ha	V cu.m/ha	N ths/ha	V cu.m/ha	N ths/ha	V cu.m/ha
Control sample plot	5,8	258,3	3,4	309,0	2,8	393,0
Free thinning	4,7	276,7	3,2	316,4	1,9	436,1
Linear-selection thinning with cutting out:						
every 3-rd row	4,4	244,5	2,8	316,5	2,2	500,8
every 4-th row	4,4	251,1	2,8	373,5	2,0	547,6
every 5-th row	4,5	255,6	3,8	362,8	2,3	524,7
every 6-th row	4,8	262,5	3,1	343,7	1,9	498,8

In 1983, largest total timber volume (V) - 276,7m^3/ha (Table 2) and V_{lm} - 178.7 m^3/ha (64.6% of V) (Fig. 2) were accumulated in the stands treated with free first thinning. V_{lm} varied between 155.8 m^3/ha and 162.4 m^3/ha (61.6-64.7%) in the stands treated with row-selection thinning. Higher values by the former stands were due to entirely individual approach by free thinning and unfavorable balance between removed volume of entire rows and still slow mean volume increment produced in response to release by residual trees along corridors in schematically treated plots. Large merchantable timber volume in the plots was negligible.

In 1993 the volumes of large and medium merchantable timber in schematically thinned plots (Fig. 2) were 30-65 m^3/ha higher than in the stands thinned only selectively. The share of V_{lm} in the stands with cut-out rows was 48.5-53.9% - a bit higher than in the plots treated with free first thinning (43.1%).

Figure 2. Dynamics of the volume of large and medium-sized (Vlm) and of only large-sized (Vl) merchantable timber in the sample plots during a period of 30 years (1973-2003)



These results are explicable with already set-in accelerated increment of drastically released peripheral trees and higher total thinning intensity applied in most of the stands treated with linear-selection first thinning (Table 1). The shares of large-size merchantable timber were small (1.8-6.5% of V).

In 2003 the volumes of large and medium-size merchantable timber in schematically thinned stands (Fig. 2) were 34–79 m^3/ha higher than in thinned by selection only. A trend is noticeable towards evening out of the volume shares of these categories (V_{lm} 69.9-74.8% of V) in all thinned stands. The share of large merchantable timber was larger in stands that reached 2003 with lowest stand densities: first thinned with cutting-out every 4th row (V_l 31.3%), with cutting-out every 6th row (29.4 %) and in thinned by selection only (26.0 %) (Table 2).

4. CONCLUSIONS

1. In 2003 in sample plots in 47 years old Scots pine plantation of medium productive capacity long-term after-effects from early linear-selection first thinning were found. In stands where in 1973 thinning with cutting out every 4th, 5th or 6th row have been carried out, percentages

of large and medium-sized merchantable timber volumes (from total timber volumes) in 2003 were with 2.0% - 4.1% higher and of large timber volume alone - with 4.3% - 9.1% higher in trees growing along corridors than in trees from inner rows in the coulisses.

2. Two subsequent thinnings of low to medium degree after first treatment parallel with self-thinning processes in the plots till 2003 resulted in:

- formation of medium and large merchantable timber volumes with 34–79 m^3/ha higher in stands tended with linear-selection first thinning than in the treated with only selection thinning;
- evening out of the shares of large and medium-sized timber total volume (varying between 69.9% and 74.8% of the total timber volume) in all thinned stands;
- higher percentages of large merchantable timber volume in stands that reached 2003 with lowest densities.

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STOMATAL VARIABILITY OF COMMON OAK (*QUERCUS ROBUR* L.) TREES WITH SUMMER FLOWERING

Branislava BATOS[1], Martin BOBINAC[2], Dragica VILOTIĆ[2]

Abstract: *Summer flowering of common oak is a natural rarity, as it has been rarely observed over the wider area of its natural range of distribution. Based on the previous studies, this phenomenon can be categorised as an ancestral (atavistic) property, and its study contributes to a better understanding of the common oak intraspecific variation. It has an essential significance for the explanation of the species phylogeny of the Quercus genus. The observed common oak flowering transformation was the base for a more in-depth research of its morpho-physiological characters and a more complete insight in its genotype. This paper analyses the microscopic characteristics of stomata on the leaves of one spring phase and two summer phases of growth of the tree with summer flowering and the neighbouring control tree without summer flowering. Based on the results of morphometric analysis of the stomatal density and stomatal dimensions, it can be concluded that the statistically significant differences in stomatal dimensions (length and width of stomatal guard cells and length and width of stomatal aperture) between the analysed trees are confirmed only in the spring growth stage.*

Key words: *Q. robur* L., summer flowering, unseasonal growth, stomata

1. INTRODUCTION

Common oak (*Quercus robur* L.) occupies the largest range in Europe of all the genus *Quercus* L. species. A great number of the specific forms and varieties have differentiated (Gajić, Tešić, 1992) during the process of common oak adaptation to different site conditions. Often the individual differences within the species are much greater and more pronounced than the differences between common oak and the very similar, sessile oak (Bodens *et al.*, 1997). The high degree of ecological and genetic variation is interesting also for the systematists who today, by using modern methods, by chemical markers (secondary metabolites, DNA analysis), succeed in a more precise classification of individuals to a genus, species or an intraspecific subgroup (Gomory *et al.*, 2001, Scalbert, Haslam, 1987).

One of the characteristic traits of common oak is its polyphase growth, i.e. polyphase formation of annual shoots, which is manifested in different phases of ontogenetic development. However, generative organs develop very rarely on summer shoots (Bobinac, 1994). According to Bobinac, Tucović, (2005) the phenomenon of common oak summer flowering was detected on only one out of 134 observed trees in the area of Belgrade and only on one of 85 incorporated clones, and one ramet of that clone in the clonal seed orchard in the area of Sremska Mitrovica. The phenomenon of summer flowering can be classified as an ancestral (atavistic) characteristic, and its study should contribute to a better understanding of common oak intraspecific variation

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and it has an essential significance for the explanation of the species phylogeny in the *Quercus* genus.

This study deals with a common oak tree with frequent polyphase growth and summer flowering. The following research of this tree was performed previously: individual variation of inflorescences in spring flowering (Tucović A. *et al.*, 2002), specific transformation of inflorescences and flowers in summer flowering (Bobinac, Tucović, 2003, Bobinac *et al.*, 2000, 2001), and morpho-physiological characteristics of pollen (Batos B. *et al.*, 2006). The above studies are the base for further morpho-anatomic study in the aim of the more complete insight into its genotype and the explanation of this phenomenon.

2. MATERIAL AND METHOD

The morpho-anatomic variation of stomata was analysed for the tree with summer flowering (tree no. 1), and the control tree in which this phenomenon has not yet been observed (tree no. 2). In both trees, polyphase formation of annual shoots is frequent, but with different intensities. Both trees develop in the same environmental conditions, they are approximately the same age, the same crown dimension and form, and they are in full physiological maturity. The results of the comparative phenological monitoring at the study site indicate that the selected tree with frequent summer flowering belongs to the late form of common oak, and the control tree belongs to the early form of common oak.

During 2006, the leaves formed on shoots during the spring (phase I) and two summer growth stages (phases II and III) were sampled from the tree no. 1, and the leaves formed on shoots during the spring (phase I) and one summer stage growth (phase II) from the tree no. 2. The leaves were sampled at least one month after the beginning of the growth stage, i.e. when the leaves were already completely formed. Ten leaves were collected from each growth stage from the lower third of the crown, from the same exposure. The impression of the epidermis was taken of the lower side of the leaf, its central part along the main vein (dimension 5.0*cm* x 1.5*cm*) by the "collodium method" (Jelenić, Džamić, 1989) and it was used for the stomatal analysis. On each leaf, i.e. impression, the stomatal density (pcs·mm^{-2}) and stomatal dimensions (μm) were measured in 3 randomly selected fields of view. The length (A) and width (B) of stomatal guard cells, the length (C) and width (D) of stomatal apertures were measured on the random sample of 5 stomata in the field of view. The total number of measured stomata was 450 stomata on tree no. 1, and 300 stomata on tree no. 2.

The statistical processing (summary statistics, analysis of variance and t-test) was performed for the level - tree, and for the level - growth phase.

3. RESULTS WITH DISCUSSION

The mean value of stomatal density per unit area and their dimensions per growth phases, for each tree, are presented in Diagrams 1 and 2. Tree no. 1 has a lower stomatal density per unit area compared to tree no. 2 at all study levels. However, the statistically significant differences in stomatal densities between the analysed trees were recorded only in the spring growth stage (phase I). In the first summer stage (phase II), there was no statistically significant difference in stomatal density between the tree no. 1, although lower, and tree no. 2 (Table 1).

The statistically significant differences in stomatal dimensions (length and width of guard cells and length and width of stomatal aperture) between the analysed trees were confirmed only in the spring stage of growth (phase I).

Table 1. Stomatal variation between analysed trees

Level - tree				Level - growth stage								
				I			II			III		
No. 1		No. 2	P-value	No. 1	No. 2	P-value	No. 1	No. 2	P-value	No. 1	No. 2	P-value
N	337.2a	399.1b	0.0000	328.4a	427.5 b	0.0000	346.1a	370.7a	0.0621	306.5	-	-
A	25.0a	23.8b	0.0000	26.4a	23.6b	0.0000	23.5a	23.9a	0.2843	24.4	-	-
B	19.7a	18.9b	0.0000	20.4a	18.6b	0.0000	19.1a	19.2a	0.6075	19.7	-	-
C	14.2a	13.2b	0.0000	15.1a	13.1b	0.0000	13.3a	13.4a	0.6745	14.2	-	-
D	4.0a	3.9a	0.0549	4.2a	3.8b	0.0010	3.9a	4.0a	0.3882	3.7	-	-

N-stomatal density (pcs·mm^{-2})
A-guard cell length (μm), B-guard cell width (μm), C-length of stomatal aperture (μm), D-width of stomatal aperture(μm)
LSD-test α=0,05

Within the same tree, and between the individual phases of growth, the statistically significant differences in stomatal density and dimensions were confirmed only for the tree no. 1. Between individual phases of growth in tree no. 2, statistically significant differences were measured only for stomatal density, width of guard cells and width of stomatal aperture (Table 2).

Based on the analysis of the parameters used for the determination of stomatal variation, intra and inter common oak trees, the obtained differences are statistically highly justified, which points to a different genetic base, but also to an identical response to the exogenous effects.

According to the literature data, the stomatal morpho-anatomical characters are under genetic control, although they can also be environmentally related, taking into account their function and position. In this study, the environmental effect is reduced to a minimum by the selection of the trees, and by collecting the samples in identical environmental conditions, so the

Table 2. Stomatal variation per growth phases within a tree

Parametars		Tree					
		No. 1			No. 2		
		Growth stage	LS-Mean	P-value	Growth stage	LS-Mean	P-value
Stomatal density (pcs·mm-2)		III	306.5 a	0.0085	II	370.7 a	0.0006
		I	328.4 ab		I	427.5 b	
		II	346.1 b				
Stomatal dimensions (μm)	A	II	23.5 a	0.0000	I	23.6 a	0.5362
		III	24.4 b		II	23.9 a	
		I	26.4 c				
	B	II	19.1 a	0.0000	I	18.6 a	0.0109
		III	19.7 b		II	19.2 b	
		I	20.4 c				
	C	II	13.3 a	0.0000	I	13.1 a	0.3378
		III	14.2 b		II	13.4 a	
		I	15.1 c				
	D	III	3.7 a	0.0002	I	3.8 a	0.0396
		II	3.9 a		II	4.0 b	
		I	4.2 b				

Diagram 1. Variation of stomatal number

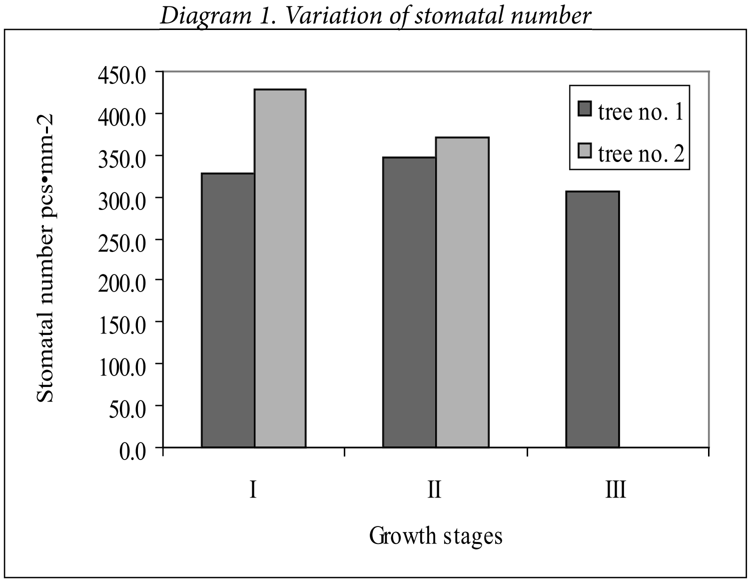
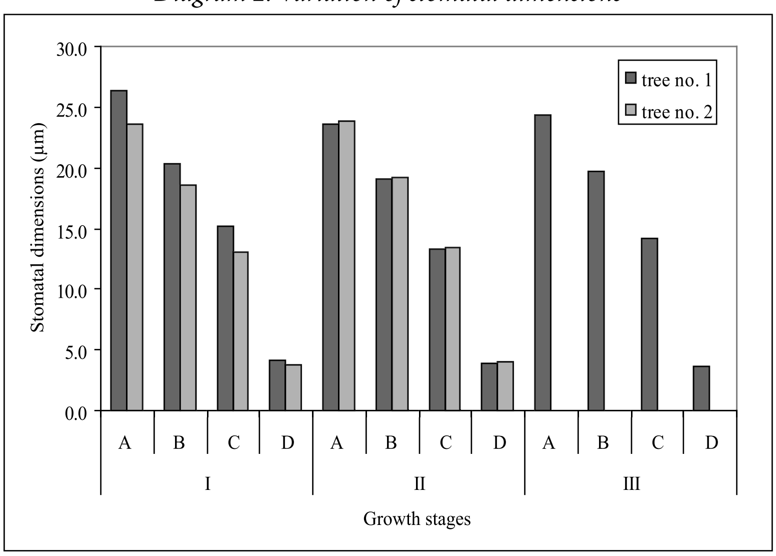


Diagram 2. Variation of stomatal dimensions



A-guard cell length, B-guard cell width,
C-length of stomatal aperture, D-width of stomatal aperture

measured differences can largely be considered as genotypic. However, the observed statistically significant differences in stomatal density and dimensions between the analysed trees only in the spring growth stage, and not also in the summer growth stage (when their induction starts in approximately the same time period, i.e. in the similar climate conditions) indicate that their variation is under the effect of environmental factors.

The more complete explanation and understanding of the genotype of the common oak tree with summer flowering requires a more in-depth study of its morpho-physiological characteristics and their correlations, as well as the continuous monitoring of its phenology.

The results of the study of anatomical-physiological variation of stomata in poplar clones indicate that stomatal number is under high degree of genetic control (Orlović, 1992). In the analysis of genotype variation of common oak clones in seed orchard, Nikolić (2002) reports that stomatal number (530-791 $pcs \cdot mm^{-2}$) is a more variable character than its dimensions - lengths and widths of stomatal guard cells (26.0 – 19.1μm), as well as that these characters are genetically conditioned. The anatomic changes of the leaf, such as the thickened cuticle, changes of epidermis and stomata, point to the adaptation to the urban stress conditions and they are bioindicators of the effects of pollutants. In the analysis of the effect of urban environment on common oak development, a group of authors (Mitrović *et al.*, 1997) report that stomatal number in an urban park in Belgrade area (148.6 $pcs \cdot mm^{-2}$) was higher compared to the stomatal number in the conditions of natural site - Mt. Maljen Serbia (133.7 $pcs \cdot mm^{-2}$). However, the determined stomatal density is significantly lower compared to the results presented in this study and the results reported by Nikolić (2002).

4. CONCLUSION

The stomatal density and dimensions on the study common oak trees are the products of the complex system of interactions. The results on the stomatal density and dimensions elucidate the genotype of the selected common oak tree with summer flowering.

The calculated statistical highly significant differences in the stomatal density and dimensions between and within the analysed common oak trees show that the above parameters can be used in the defining of the degree of intraspecific variability. However, to provide the equivalent material for the comparative morpho-physiological study of stomatal intraspecific variation in common oak, the assimilation apparatus should be formed in identical environmental conditions and under identical conditions of growth. In common oak, the spring and summer shoots - polyphase growth are the base for the defining of the equivalent sample for the analysis.

The above research is a contribution to the methodology of the study of common oak intraspecific variation. They specify that the comparative morpho-physiological study of stomatal intraspecific variation of common oak should be performed on the leaf samples from phase shoots, which are induced under identical growth conditions.

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STATE AND SILVICULTURAL GOALS IN COPPICE FORESTS OF HUNGARIAN OAK AND TURKISH OAK IN THE AREA OF LIPOVICA – BELGRADE

Marina VUKIN, Ivan BJELANOVIĆ [1]

Abstract: *The state and silvicultural goals of a coppice climatogenic forest of Hungarian oak and Turkish oak were researched in Lipovica near Belgrade. The study stand typology is as follows: Typical forest of Hungarian oak and Turkish oak (Quercetum farnetto-cerris aculeatetosum) on lessivé brown forest soil. The study was performed in two different stand situations, Hungarian oak is dominant in one stand, and Turkish oak in the other. Site conditions, stand state, development of individual trees and the stand quality were studied in detail. The number of trees is from 427 to 688 per ha, basal area about 30 m²/ha, wood volume 311.5 to 365.9 m³/ha, average volume increment from 3.30 to 4.93 m³/ha, increment percentage from 1.06 to 1.35%, and the age is about 60 - 65years. Taking into account that the forests of Hungarian oak and Turkish oak are climatogenic forests in Serbia, that the greatest part of Hungarian oak and Turkish oak forests is of coppice origin, and that they are in the vicinity of the major urban environments, these forests are subject to special-purpose forest management in the aim of fulfilling all the multiple forest functions. Based on the above facts, the optimal silvicultural method was determined, bearing in mind the significance of these forests for the area of Belgrade.*

Key words: forest of Hungarian oak and Turkish oak, stand state, silvicultural operations, conversion.

1. INTRODUCTION, PROBLEM AND TASK

The overutilisation of forest resources around large towns, during several decades, and even centuries, has caused the degradation, or even the complete destruction, of vast forest areas. The complex of Hungarian oak and Turkey oak forests (*Quercetum farnetto-cerris*) in Serbia, a climatogenic forest or a coeno-ecological synonym for the central region of the Republic and the most frequent forests around large towns, also include the forests managed for specific purposes. The forests of Hungarian oak and Turkey oak in Belgrade area occupy a special place in the complex measures prescribed and applied for the management of special purpose forests in Serbia. They are highly degraded even-aged forests, almost exclusively of vegetative origin, of poor quality and unsatisfactory health. Today the city area has only 22,064 ha of state forests and about 15,000 ha of private forests. According to the Spatial Plan of the Republic of Serbia, it is necessary to establish another 50,000 ha of forest area for the maintenance of multiple use forest functions.

The above facts point to the need for radical silvicultural operations to optimise i.e. to enhance the state of these forests. The priority social and ecological functions indicate the immeasurable significance of these suburban forests in the so-called 'green background' of the capital - by all means a modern European metropolis, with all socio-ecological problems which accompany its development. Considering the fast spreading of both the narrow and the wider core of the city, enormous increase of the population number and insufficient forest cover percentage in Belgrade

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territory (Medarević, M., 2006; Živadinović, V., Isajev, D., 2006), the actual statistical data indicate that the area of present suburban forests are very soon going to be converted into urban zone.

Based on the above, the problem and the task of this study are as follows:

- Study the site characteristics of the stands;
- Determine the present state of the stands, the development of individual trees and the stand quality;
- Propose the silvicultural goals and measures for the improvement of the state of the concrete stands.

2. METHOD AND MATERIAL

The mixed coppice forest of Hungarian oak and Turkey oak was researched in MU Lipovica, compartments 31 and 37. The data were collected during 2006, by the principle of permanent sample plots. The research covered two stands differing in the ratio of edificators in the mixture, with Hungarian oak prevailing in one and Turkey oak in the other.

The study included site conditions, stand state, development of individual trees, biological position and stand quality. The diameters of all trees were measured. The heights were measured and the cores were taken from only the necessary number of trees in each diameter degree, for the construction of the height curve and fitting the line of diameter increment. The diameter analysis was performed on mean stand trees of 20% largest trees in the stand, i.e. 3 trees each of Hungarian oak and Turkey oak. The data were processed by usual methodology applied in this type of research.

3. RESULTS AND DISCUSSION

3.1 Basic data on the site and the stand

The study stands range at the altitude of 260 - 270 m, mild slope up to 8°, exposure South to North-West and the canopy is complete (0.7). Bedrock consists of calcareous sandstones with quartz, and the soil is lessivé brown forest soil. Such orographic and edaphic conditions, in the greatest part of Lipovica, represent the most productive sites for Hungarian oak and Turkey oak, which are typologically defined as: Typical forest of Hungarian oak and Turkish oak *(Quercetum farnetto-cerris aculeatetosum)* on lessivé brown forest soil (Jović, N. *et al.*, 1996).

Coppice forests of Hungarian oak and Turkey oak were created after clear felling during the Second World War and now they are about 60-65 years old. The sample plots are established in the most conserved parts of the stands, where Hungarian oak or Turkey oak prevails. Depending on the percentage of the main species, there is a series of transitions between the extreme situations.

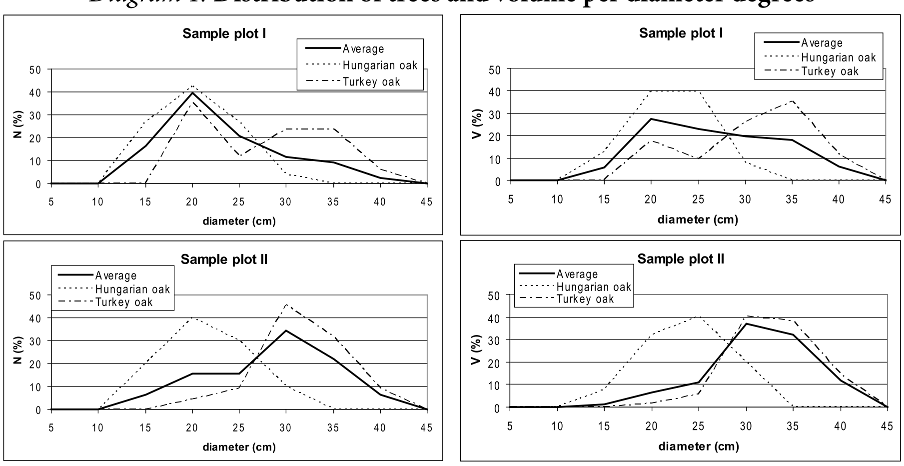
3.2 Stand state and structure

The number of trees in the stand with prevailing Hungarian oak, on sample plot I, is 688 per ha, of which Hungarian oak is 415 per ha or 60.5%, and Turkey oak 272 per ha, or 39.5% (Table 1). The other stand, with prevailing Turkey oak, has a thin canopy and there are 427 trees per ha, of which Hungarian oak 133 trees per ha or 31.2%, and Turkey oak 293 trees per ha, or 68.8% (Table 2). In both stands, the trees are distributed per diameter degrees from 15 cm to 40 cm, the maximum percentage in the first stand is in the diameter degree of 20 cm - 39.5%, and in the second stand, it is in the diameter degree of 30 cm - 34.4%. Mean stand diameter is lower in the first stand for 5.1 cm and amounts to 24.1 cm, and in the second stand it is 29.2 cm. In both stands, mean diameter of Turkey oak is larger than that of Hungarian oak, which is the consequence of the faster growth and development of this species. The lines of tree distribution per diameter degrees for both stands have the characteristics of even-aged forests, but the line for the first stand has left skewness, and the line for the second stand has right skewness, which is the consequence of thin canopy and the shortage of Hungarian oaks in the smaller diameter degrees (Diagram 1).

Wood volume in the first stand, on sample plot I, is 365.83 m^3/ha, with the percentage of Hungarian oak - 44.4% and Turkey oak - 55.6%. Wood volume in the second stand is 311.45 m^3/ha, and only 15.9% of Hungarian oak, and 84.1% of Turkey oak. The line of tree distribution per diameter degrees is characteristic for even-aged forest, with clearly expressed maximum in the diameter degree of 20 cm with 27.5%, i.e. 30 cm with 37.0% (Diagram 1). As Hungarian oak has a higher increment percentage, current volume increment in the first stand is 4.93 m^3/ha and it is greater than in the second stand, where it amounts to 3.30 m^3/ha.

Similar results in coppice forests of Hungarian oak and Turkey oak in Serbia were reported by Stojanović, Lj. (1987), and Stojanović, Lj. *et al.* (2006), etc., especially for the stands in favourable site conditions.

Diagram 1. **Distribution of trees and volume per diameter degrees**



3.3 Development of diameter and current diameter increment

The lines of diameter development and current diameter increment of the study trees are presented in Diagram 2. The diameter development of all three trees of Hungarian oak and Turkey oak has identical course and clearly shows the difference in bio-ecological characteristics of the species. Turkey oak has faster increment from the beginning and the difference increases with the increase of age, which is the consequence of the reduced life space of Hungarian oaks.

The first culmination of current diameter increment occurs early, in Hungarian oak between 5 and 10 and in Turkey oak between 10 and 15, which characterises the trees of coppice origin. The course of current diameter increment after the culmination slowly declines which reflects the very high site productivity. The variation of current diameter increment after the culmination is also the consequence of the coppice origin and the response to thinning. The value of current diameter increment during the culmination is higher in Turkey oak by about 40% and it amounts to 8.0 mm, and in Hungarian oak it is 5.7 mm.

Table 1. Basic data on the stand

MU Lipovica							compartment 31a							series I sample plot I						
altitude: 270 m							slope: 8°							exposure: West-Northwest						
TYPOLOGY: Typical forest of Hungarian oak and Turkey oak (Quercetum farnetto-cerris aculeatetosum) on lessivé brown forest soil																				
Diam. degr. (cm)	Hungarian oak				Turkey oak				total				future trees				marked trees			
	N		V (m3)		N		V (m3)		N		V (m3)		N		V (m3)		N		V (m3)	
	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%
5	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00
10	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00
15	112	26.9	20.42	12.56	0	0.0	0.00	0.00	112	16.3	20.42	5.58	0	0.0	0.00	0.00	48	42.9	8.75	22.45
20	176	42.3	64.58	39.72	96	35.3	36.17	17.80	272	39.5	100.75	27.54	16	14.3	5.87	9.04	32	28.6	11.74	30.12
25	112	26.9	64.70	39.80	32	11.8	18.80	9.25	144	20.9	83.50	22.82	80	71.4	46.22	71.15	32	28.6	18.49	47.43
30	16	3.9	12.87	7.91	64	23.5	53.52	26.33	80	11.6	71.74	19.61	16	14.3	12.87	19.81	0	0.0	0.00	0.00
35	0	0.0	0.00	0.00	64	23.5	71.74	35.29	64	9.3	66.39	18.15	0	0.0	0.00	0.00	0	0.0	0.00	0.00
40	0	0.0	0.00	0.00	16	5.9	23.04	11.34	16	2.3	23.04	6.30	0	0.0	0.00	0.00	0	0.0	0.00	0.00
Σ	416	100	162.57	100	272	100	203.26	100	688	100	365.83	100	112	100	64.95	100	112	100	38.98	100
	dg = 20.80 cm				dg = 28.44 cm				dg = 24.11 cm				dg = 25.14 cm				dg = 19.73 cm			
	hdg = 23.9 m				hdg = 26.7 m				hdg = 25.4 m				hdg = 25.4 m				hdg = 23.3 m			
	Iv = 2.48 m3/ha				Iv = 2.45 m3/ha				Iv = 4.93 m3/ha				Iv = 0.95 m3/ha				Iv = 0.60 m3/ha			
	Piv = 1.53%				Piv = 1.21%				Piv = 1.35%				Piv = 1.47%				Piv = 1.54%			
	Hungarian oak % in mixture				Turkey oak % in mixture								future trees %				marked trees %			
	per N = 60.5%				per N = 39.5%								per N = 16.3%				per N = 16.3%			
	per V = 44.4%				per V = 55.6%								per V = 17.8%				per V = 10.7%			

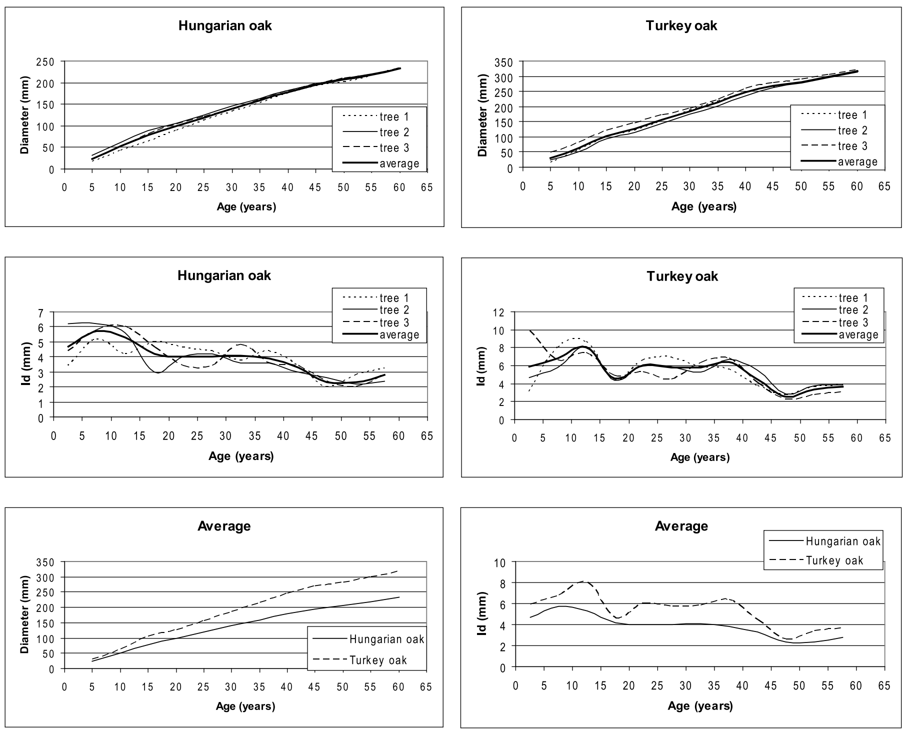
Table 2. Basic data on the stand

MU Lipovica					compartment 37a				series I sample plot II			
altitude: 260 m					slope: 3°				exposure: South			
TYPOLOGY: Typical forest Hungarian oak and Turkey oak (*Quercetum farnetto-cerris aculeatetosum*) on brown forest soil lessivé												
Diam. degr. (cm)	Turkey oak				Hungarian oak				total			
	N		V (m^3)		N		V (m^3)		N		V (m^3)	
	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%
5	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00
10	0	0.0	0.00	0.00	0	0.0	0.00	0.00	0	0.0	0.00	0.00
15	0	0.0	0.00	0.00	27	20.0	3.78	7.63	27	6.3	3.78	1.21
20	13	4.5	4.66	1.78	53	40.0	15.95	32.23	67	15.6	20.61	6.62
25	27	9.1	14.67	5.60	40	30.0	19.99	40.40	67	15.6	34.65	11.13
30	133	45.5	105.53	40.28	13	10.0	9.77	19.74	147	34.4	115.30	37.02
35	93	31.8	100.05	38.19	0	0.0	0.00	0.00	93	21.9	100.05	32.12
40	27	9.1	37.07	14.15	0	0.0	0.00	0.00	27	6.3	37.06	11.90
Σ	293	100	261.97	100	133	100	49.48	100	427	100	311.45	100
	d_g = 31.93 cm				d_g = 21.97 cm				d_g = 29.18 cm			
	h_{dg} = 25.6 m				h_{dg} = 19.5 m				h_{dg} = 25.0 m			
	I_v = 2.50 m^3/ha				I_v = 0.80 m^3/ha				I_v = 3.30 m^3/ha			
	P_{iv} = 0.95%				P_{iv} = 1.62%				P_{iv} = 1.06%			
	Turkey oak % in mixture				Hungarian oak % in mixture							
	per N = 68.8%				per N = 31.2%							
	per V = 84.1%				per V = 15.9%							

3.4 Proposal of silvicultural measures

The presented data on stem and crown biological position and quality (Table 3) show that the second stand has fewer trees of the second and third biological positions, because of the previous thinning, i.e. mainly low thinning. Stem quality in the second stand is somewhat better, i.e. in the first stand the percentage of trees with poor stem is 48.8%, and in the second stand it is 34.4%. In the second stand, there are more trees with good and medium stems. Crown quality is also different, in the first stand there are more trees with poor crowns, and less with good crowns, while the percentages of medium quality crowns are equal. The differences in stem and crown quality result from the fact that the percentage of Hungarian oak is higher in the first stand, and it has a slower development and less space for growth.

Diagram 2. Diameter development and current increment



In the first stand, 112 future trees were selected per ha, which represents 16.3% of the total number of trees, i.e. 17.8% per volume. The trees were selected from the dominant part of the stand, which is seen from the mean diameter, which is greater than the mean stand diameter for 1.03 cm. Their number is almost at the lower limit for the conversion. In the following period, we propose the thinning of moderate thinning weight of 16.3% per N and 10.7% per V, and later on, start the natural regeneration by regeneration cutting, i.e. convert this stand into a forest of high silvicultural form, by conversion.

In the second stand, future trees were not selected because there are no Hungarian oaks in the upper-production part of the stand i.e. there is not a sufficient number of trees which would remain till the end of the rotation. The proposed measure is artificial regeneration by Hungarian oak restitution and by the substitution of suitable species.

Table 3. Biological position of trees, stem and crown quality

	Biological position %	Stem quality %	Crown quality %
Sample plot I			
1 - good	46,5	23,3	20,9
2 - medium	41,9	27,9	46,5
3 - poor	11,6	48,8	32,6
Sample plot II			
1 - good	65,6	28,1	28,1
2 - medium	28,1	37,5	46,9
3 - poor	6,3	34,4	25,0

Figure 1. Coppice stand of Hungarian oak and Turkey oak, Sample plot II

Based on the analysis of stand state, diameter development and stand quality, the proposal of the most favourable silvicultural operations in the coppice forests of Hungarian oak and Turkey oak in Lipovica (Figure 1), is as follows:

- Conversion of the silvicultural form in the conserved parts with a sufficient number of good-quality Hungarian oak trees;
- In the stand parts of poorer quality, as well as in the stands where Turkey oak is dominant, artificial regeneration by restitution of Hungarian oak, or by introducing the suitable tree species with the properties which will be in harmony with the special purpose of these forests (Isajev, V. *et al.*, 2006);
- Establishment of all-aged composition, due to the fact that the stand age is 60-65 years on a great part of the area, i.e. that all forests in Lipovica are even-aged. This can be achieved by the combined regeneration method, Femelschlagbetrieb. The regeneration should start im-

mediately in the poorest parts, and in the best parts regeneration should be postponed for later on, with the general regeneration period up to 60 years (Stojanović, Lj. *et al.*, 2006).

4. CONCLUSIONS

The following conclusions were made based on study in Hungarian oak and Turkey oak coppice forest aged 60-65 years, in the area of Lipovica:

Typology: Typical forest of Hungarian oak and Turkey oak (*Quercetum farnetto-cerris aculeatetosum*) on lessivé brown forest soil.

The stand with dominant Hungarian oak - sample plot I: total number of trees is 688 per ha, of which 60.5% Hungarian oak, 39.5% Turkey oak. Wood volume is 365.8 m^3/ha, of which Hungarian oak is 44.4%, and Turkey oak is 55.6%. Current volume increment is 4.93 m^3/ha. There are 112 future trees per ha. The proposed measure is thinning of moderate weight of 16.3% per N and 10.7% per V, and later on, by the regeneration cutting, the conversion into a higher silvicultural form.

The stand with dominant Turkey oak - sample plot II: total number of trees is 427 per ha, of which Turkey oak 68.8%, Hungarian oak 31.2%. Wood volume is 311.5 m^3/ha, of which Turkey oak 84.1%, Hungarian oak 15.9%. Current volume increment is 3.30 m^3/ha. The proposed measure is conversion into a higher silvicultural form by the combination of restitution and substitution.

All-aged forests should be established by the combined regeneration method, Femelschlagbetrieb. The regeneration should start immediately in the poorest parts, and in the best parts regeneration should be postponed.

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SILVICULTURAL PROBLEMS IN SESSILE OAK FORESTS IN THE AREA OF TRSTENIK

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Abstract: *The silvicultural issues in sessile oak (Quercus petraea Matt. Liebl.) forests within the «Trsteničke Šume» in the area of the FE «Rasina» Kruševac are presented. The research is carried out in the stands at the altitude of 385 m, on the slope of 20-25º, and south-southeast exposure. Based on ecological-vegetation research, the stand is typologically defined as: Forest of sessile oak with oriental hornbeam (Quercetum montanum carpinetosum orientalis) on brownised dystric ranker. The stand is of coppice origin, aged about 60 years, of broken canopy. It is on the transient site of oak forests of sessile oak, Hungarian oak and Turkish oak, so it is a mixed stand. The total number of trees is 736 per ha, with the percentage of sessile oak 76%, Hungarian oak 22% and Turkish oak 2%. Total volume is 240 m³/ha of which sessile oak 78%, Hungarian oak 17% and Turkish oak 5%. The underwood layer consists of oriental hornbeam (Carpinus orientalis). The analysis of the stand and health condition shows that it is a good-quality coppice stand on a good site which, by the conversion of silvicultural form, should be converted into a high good-quality forest of sessile oak, which is the final silvicultural goal. The stand should be tended till the end of the rotation, and then by regeneration cutting it should be regenerated by seeding. To this purpose, 160 future trees per ha were selected in the stand, which is 225 per tree number and 31% per the volume of the proposed silvicultural measure.*

Key words: oaks, sessile oak and Hungarian oak, structure, development, conversion

1. INTRODUCTION, PROBLEM AND OBJECTIVE

The percentage of coppice forests in the growing stock in Serbia is very high and accounts for more than 30% of the total forest area. If degraded forests, scrub, shrub and brushland are taken into account, it is more than 50% of the total growing stock of Serbia.

After beech forests, which occupy the largest area, oak forests hold the second position, of which a considerable part are coppice forests of sessile oak and Hungarian oak with Turkey oak.

Sessile oak forests in Serbia range within a special oro-climatogenic altitudinal belt, above the climatogenic forests of Hungarian oak and Turkey oak. Sessile oak forests cover the upper part of the submontane belt and the lower montane belt at the altitudes of 300-1300 m.

Silvicultural issues and conversion of sessile oak coppice forests into high forests in Serbia were dealt with by S t o j a n o v i ć, LJ *et al.* (1980, 2005, 2006), Krstić, M. (1989, 1998), Krstić, M. *et al.* (1996, 1997, 1998, 2006) etc. However, a more in-depth survey of references referring to the conversion of sessile oak forests shows that it was insufficiently investigated in this region.

Based on the above, the tasks of this study regarding the silvicultural operations in sessile oak coppice forests in the study area, are as follows:

- Study the environmental conditions in the study stands;
- Research the stand state and the development of diameter and current diameter increment;
- Propose the appropriate silvicultural operations in the concrete stands.

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2. MATERIAL AND METHOD

The data for this study were collected in MU Trsteničke Šume, in the vicinity of Trstenik. In addition to the data on sample plot, 3 sessile oak trees were selected out of mean trees of 20% trees with the largest diameter in the stand.

The study stand of sessile oak and Hungarian oak is of coppice origin in the area of Trstenik. Field data were collected during 2006, based on the principle of work on permanent sample plots. The data were processed by the usual methods applied in the research of this character.

3. RESULTS AND DISCUSSION

3.1. Basic data on site and stand

The stands are situated in MU Trsteničke Šume, compartment 29, at the altitude of 380-400 m, slope 20-25° and exposure South-Southeast. It is a mixed forest of sessile oak and Hungarian oak with the admixture of Turkey oak, of coppice origin, aged about 60 years, of complete canopy 0.7. The percentage of sessile oak is 76%, Hungarian oak 22% and Turkey oak 2%.

Based on the soil and plant community study by Košanin, O. and Cvjetićanin, R in lit (2006), the typology of the stand is:

<u>Forest of sessile oak with hornbeam (*Quercetum montanum carpinetosum orientalis*) on brownised dystric ranker</u>.

3.2. Stand state and structure

The basic data on the study stand are presented in Table 1 and Diagram 1.

The total number of trees is 736 per ha, of which sessile oak accounts for 560 per ha or 76.1%, Hungarian oak 160 per ha or 21.7% and Turkey oak 16 trees per ha or 2.2%. All trees range within the diameter degrees of 10 cm to 30 cm, with the maximum percentage in diameter degree of 20 cm, 43.5%. The distribution line has a typical bell-shaped curve which characterises even-aged forests.

Mean stand diameter is 20.7 cm, for sessile oak 21.0 cm, for Hungarian oak 18.1 cm and for Turkey oak 30.0 cm. This indicates that Turkey oak has the best growth, then sessile oak, and Hungarian oak is the lowest.

Wood volume in the stand is 240.3 m^3/ha, of which sessile oak 188.2 m^3/ha or 78.3%, Hungarian oak 40.1 m^3/ha or 16.7% and Turkey oak 12.0 m^3/ha or 5.0%. The maximum percentage of wood volume is in the same diameter degree as the highest number of trees, i.e. in degree of 20 cm, with 39.6%. Current volume increment is 6.1 m^3/ha, of which sessile oak 4.9 m^3/ha, Hungarian oak 0.9 m^3/ha and Turkey oak 0.3 m^3/ha, and the increment percentage is 2.5%.

The presented basic data on the stand, compared to previous studies by these authors (Stojanović, LJ. *et al.*, 2006, 2005; Krstić, M. *et al.*, 2006), indicate that, despite the unfavourable site conditions, it has a high productivity, i.e. relatively high timber supply per ha.

Diagram 1. Distribution of trees and volume per diameter degrees

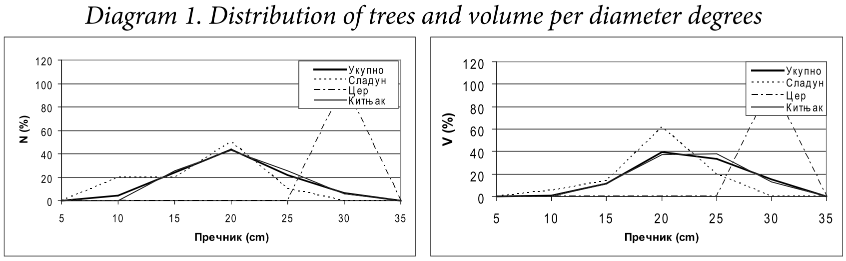


Table 1. Basic data on the study stand

MU Trsteničke Šume							Compartment 29							Series I Sample plot 1						
Altitude: 385 m							Slope: 23°							Exposure: South - Southeast						
TYPOLOGY: Forest of sessile oak with hornbeam (Quercetum montanum carpinetosum orientalis) on brownised dystric ranker																				
Diam. class (cm)	Sessile oak				Hungarian oak				Turkey oak				Total				Future trees			
	N (pcs)		V (m3)		N (pcs)		V (m3)		N (pcs)		V (m3)		N (pcs)		V (m3)		N (pcs)		V (m3)	
	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%
5	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
10	0.0	0.0	0.00	0.00	32.0	20.0	2.24	5.59	0.0	0.0	0.00	0.00	32.0	4.3	2.24	0.93	0.0	0.0	0.00	0.00
15	144.0	25.7	21.66	11.51	32.0	20.0	5.34	13.33	0.0	0.0	0.00	0.00	176.0	23.9	27.00	11.24	0.0	0.0	0.00	0.00
20	240.0	42.9	70.63	37.53	80.0	50.0	24.64	61.49	0.0	0.0	0.00	0.00	320.0	43.5	95.27	39.65	48.0	30.0	14.13	19.09
25	144.0	25.7	71.53	38.01	16.0	10.0	7.85	19.59	0.0	0.0	0.00	0.00	160.0	21.7	79.37	33.04	96.0	60.0	47.68	64.44
30	32.0	5.7	24.39	12.96	0.0	0.0	0.00	0.00	16.0	100.0	11.99	100.00	48.0	6.5	36.38	15.14	16.0	10.0	12.19	16.48
Σ	560.0	100	188.20	100	160.0	100	40.07	100	16.0	100	11.99	100	736.0	100	240.26	100	160.0	100	74.00	100
	dg = 21.01 cm				dg = 18.10 cm				dg = 30.00 cm				dg = 20.66 cm				dg = 24.19 cm			
	hdg = 18.4 m				hdg = 18.0 m				hdg = 23.5 m				hdg = 18.2 m				hdg = 20.4 m			
	Iv = 4.94 m3/ha				Iv = 0.87 m3/ha				Iv = 0.31 m3/ha				Iv = 6.12 m3/ha				Iv = 2.07 m3/ha			
	Piv = 2.63%				Piv = 2.17%				Piv = 2.59%				Piv = 2.55%				Piv = 2.79%			
	Sessile oak percentage in mixture				Hungarian oak percentage in mixture				Turkey oak percentage in mixture								Percentage of future trees			
	Po N = 76.1%				Po N = 21.7%				Po N = 2.2%								Po N = 21.7%			
	Po V = 78.3%				Po V = 16.7%				Po V = 5.0%								Po V = 30.8%			

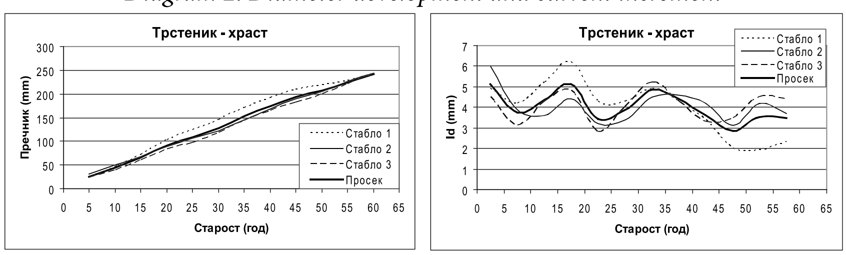
3.3. Development of diameter and current diameter increment of sessile oak trees

The dendrometric analysis was performed on three mean trees of 20% trees with the largest diameter in the sessile oak stand, to determine the development of diameter and current diameter increment (Diagram 2).

The diameter development of all three trees has an identical course about the mean value, with slight deviation between the ages of 20 and 50 years.

The line of current diameter increment, which is identical in all three analysed trees, shows the following. After the early culmination till the age of 5, the second culmination is reached about the age of 15 years, the third about 30-35 years and the fourth about 50-55 years of age. The above line of current diameter increment could be explained on the one hand by biological characteristics of coppice sessile oak trees, and on the other hand by thinning in each management period.

Diagram 2. Diameter development and current increment



3.4. Proposal of silvicultural measures

In the study stand, 160 future trees were selected per ha, which accounts for 21.7% of all trees in the stand. Wood volume percentage of future trees is 74 m^3/ha or 30.8% of the total volume. Mean diameter of these trees is 24.2 cm and it is larger than mean stand diameter for 3.8 cm, which indicates that these trees were selected in the production part of the stand.

Table 2. Biological position of trees, stem and crown quality

	Biological position %	Stem quality %	Crown quality %
1 - good	56.5	39.1	15.2
2 - mean	39.1	45.7	23.9
3 - poor	4.4	15.2	60.9

The quality evaluation of the stand (*Table 2*) shows that the trees with good-quality stem account for almost 40%, but the trees with good-quality crowns account for 15% which is the consequence of the absence of timely thinning, so the crowns are reduced.

The low percentage of trees of the third biological position of only 4.4%, indicates that this tree species cannot tolerate the shade, particularly in unfavourable site conditions.

In the study stand of sessile oak and Hungarian oak, based on the evaluation of stand quality, there is a sufficient number of future trees (160 per ha) to start the conversion, i.e. after another thinning, natural regeneration should be undertaken by regeneration cutting together with the new stand obtained from seeds from the trees of coppice origin. In this way, this stand of coppice origin would be converted into a high forest, by conversion. In the framework of thinning, i.e. preparatory felling for regeneration cutting, it is necessary to remove the seedlings of oriental hornbeam in the aim of correct development of sessile oak and Hungarian oak regeneration, which require a substantial quantity of light for correct development.

4. CONCLUSIONS

Based on the environmental conditions, the study coppice stand of sessile oak and Hungarian oak in the area of MU Trsteničke Šume, aged about 60 years, is typologically described as: Forest of sessile oak with hornbeam (*Quercetum montanum carpinetosum orientalis*) on brownised dystric ranker.

Total number of trees is 736 per ha, percentage of sessile oak is 76.1%, Hungarian oak 27.1% and Turkey oak 2.2%. Mean stand diameter is 20.7 cm, sessile oak 21.0 cm, Hungarian oak 18.1 cm and Turkey oak 30.0 cm, which shows that Hungarian oak has the slowest growth, followed by sessile oak, and Turkey oak has the best growth.

Wood volume is 240.3 m^3/ha, of which sessile oak percentage is 78.3%, Hungarian oak 16.7% and Turkey oak 5.0%. Current volume increment is 6.1 m^3/ha, and increment percentage is 2.5%. The culminations of current diameter increment occur at the ages of 5, 15, 35 and 50 years.

In the study stand, 160 future trees were selected per ha. After another thinning, regeneration cutting is proposed and the conversion of this coppice forest into a stand of high silvicultural form.

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THE STATE AND SILVICULTURAL DEMANDS OF HUNGARIAN OAK AND TURKISH OAK COPPICE FOREST IN THE AREA OF BOGOVAĐA

Snežana STAJIĆ[1]

Abstract: *In West Serbia, the percentage of coppice forests in the growing stock is high, and the percentage of Hungarian oak and Turkish oak coppice forests is great thanks to the orographic characteristics of the region. These forests were mainly formed by clear felling during the First World War. Because of their age (about 100 years), the problem of optimal methods of their regeneration is highly topical. This paper presents the results of the study of silvicultural demands and operations in coppice forests of Hungarian oak and Turkish oak in the area of Bogovađa. A series of sample plots were established in the stand of Hungarian oak and Turkish oak with hornbeam (Carpino betuli-Quercetum farnetto-cerris). The necessary silvicultural measures for the conversion of this stand into a higher silvicultural form are proposed based on an in-depth study of site conditions, typology, stand state, as well as the development of individual trees.*

Key words: forest of Hungarian oak and Turkish oak, stand state, tree development, silvicultural operations.

1. INTRODUCTION

The forest of Hungarian oak and Turkey oak *Quercetum farnetto-cerris* Rud.1949 is a climatogeneous forest in Serbia, i.e. in the East part of the Balkan Peninsula. It reflects the intersected effects of climate and vegetation of Central Europe, continental-steppe and Sub Mediterranean regions (Jovanović, 1986). The greatest number of settlements in Serbia is situated on the previous sites of this forest, so it is most closely and narrowly related to man and his adverse influences.

The forests of Bogovađa were owned by the Monastery Bogovađa till 1945, and therefore they are relatively well conserved. The highest percentage of coppice forests in this complex was created during the First World War and their age is about 90-100 years. The previous works in this complex consisted of the substitution with Weymouth pine (*Pinus strobus* L.), Douglas-fir (*Pseudotsuga menziesii* var. *viridis*), larch (*Larix decidua* Mill.), Scots pine (*Pinus silvestris* L.), Austrian pine (*Pinus nigra* Arn.), fir (*Abies alba* Mill.), Atlas cedar (*Cedrus atlantica* Man.) and Chamaecyparis (*Chamaecyparis* Spach.).

The present state is still characterised by a high percentage of coppice forests of Hungarian oak and Turkey oak. As these forests are in the direct vicinity of Monastery Bogovađa, and as they are special purpose forests, their state should be improved by the appropriate silvicultural-reclamation measures and operations. As at the moment, the state of these forests is unsatisfactory from the aspect of both quality and productivity, which also endangers other forest functions, it is necessary to apply the appropriate reclamation-silvicultural operations which will improve the existing state.

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2. STUDY AREA AND METHOD

Management Unit "Bogovađa" is situated in the upper upstream part of the Kolubara Basin, by air line about 4 km south from the Ljig confluence in the river Kolubara.

The study sample plots are established in the coppice stand of Hungarian oak and Turkey oak with hornbeam, aged 90 years. The altitude is 210-212 m, exposure South-Southwest, slope very mild – up to 3°. The canopy is incomplete to complete 0.6-0.7. Parent rock consists of lacustrine sediments (marls and slates), and the soil is deep lessivé soil with the elements of pseudogleying (pseudogleyed luvisol). Based on the in-depth study of ecological conditions, the study stand is typologically defined as:

- Forest of Hungarian oak and Turkey oak with hornbeam (*Quercetum frainetto-cerris carpinetosum betuli*) on deep lessivé soil with the elements of pseudogleying.

The taxation data were collected during 2004. by the usual method. The site conditions were studied in detail, as well as the stand state. The necessary number of 20% largest trees of both study species was felled for dendrometric analysis.

3. RESULTS AND DISCUSSION

3.1. Stand state and structure

The total number of trees in the stand is from 650 to 875 per ha, or on average 763 per ha. The number of Hungarian oak trees ranges from 225 to 400, or on average 319 per ha, which accounts for 41.8% of the total number of trees in the stand. The greatest number of trees is concentrated in two diameter classes 22.5 and 27.5 cm and they include 3/4 of the total number of Hungarian oak trees. The average number of Turkey oak trees is 194 per ha or 25.4%, and it ranges from 125 to 275 trees per ha. The maximum percentage is in the class of 27.5 cm. The number of hornbeam trees is from 150 to 325 per ha, average 250 per ha or 32.8% of the total number. The line of tree distribution in the entire stand has two maxima, its left branch and the maximum percentage of the thinnest trees is derived from hornbeam trees which belong to the lower layer and which account for as much as 32.8% of the total number of trees in the stand (Diagram 1).

Total basal area in this stand is from 21.51 m^2/ha to 37.84 m^2/ha, or average 32.76 m^2/ha. The sum of Hungarian oak basal areas is from 10.70 to 22.37 m^2/ha, or average 17.18 m^2/ha, which is 52.4% of the total basal area. Turkey oak basal area ranges from 9.48 to 20.54 m^2/ha, or average 14.48 m^2/ha, which is 44.2% of the total basal area. The percentage of hornbeam and lime basal area is only 3.4% and it ranges from 0.66 to 1.44 m^2/ha, average 1.1 m^2/ha.

Diagram 1. Distribution of trees per diameter degrees

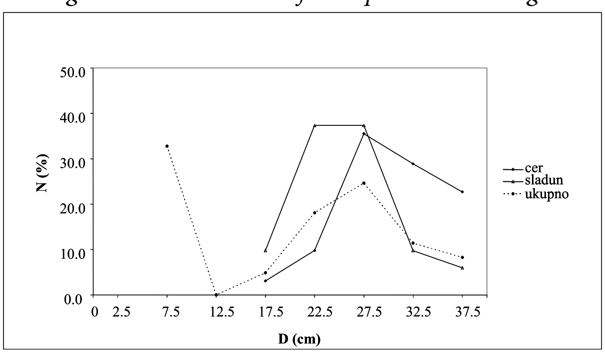


Table 1. Basic data on the study stand

	MU: "Bogovađa", compartment 10a						Altitude: 210m						Slope: 3°						Exposure: South-Southwest					
Forest of Hungarian oak and Turkey oak with hornbeam (Quercetum farnetto-cerris carpinetosum betuli) on deep lessivé soil with the elements of pseudogleying																								
INITIAL STATE																								
Diam. degree	Hungarian oak						Turkey oak						Hornbeam						Total					
	N		G		V		N		G		V		N		G		V		N		G		V	
	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%
7.5													250	100	1.10	100	7.31	100	250	32,8	1,1	3,4	7,31	1,9
12.5																								
17.5	31	9.7	0.75	4.4	7.88	4.1	6	3.1	0.15	1.0	1.80	1.0							37	4,8	0,90	2,7	9,68	2,6
22.5	119	37.3	4.72	27.5	53.85	27.6	19	9.8	0.75	5.2	9.16	5.3							138	18,1	5,47	16,7	63,01	16,8
27.5	119	37.3	7.05	41.0	81.27	41.7	69	35.5	4.08	28.2	49.82	28.8							188	24,6	11,13	34,0	131,09	34,9
32.5	31	9.7	2.59	15.1	29.27	15.0	56	28.9	4.67	32.2	55.86	32.3							87	11,4	7,26	22,1	85,13	22,7
37.5	19	6.0	2.07	12.0	22.65	11.6	44	22.7	4.83	33.4	56.52	32.6							63	8,3	6,90	21,1	79,17	21,1
sum	319	100	17.18	100	194.92	100	194	100	14.48	100	173.16	100	250	100	1.10	100	7.31	100	763	100	32,76	100	375,39	100
	Percentage				Dg=26.2 cm		Percentage				Dg=30.8 cm		Percentage				Dg=7.5cm							
	N=41.8%				Hg=25.1 m		N=25.4% per:				Hg=27.9 m		N=32.8%				Hg=8.4 m							
	per: G=52.4%						G=44.2%						G=3.4%								Iv=7.1 m3/ha			
	V=51.9%						V=46.1%						per: V=1.9%								piv=1.9%			
MARKED TREES																								
17.5	25	33.3	0.60	19.5	6.31	18.2													25	16,7	0,60	9,2	6,31	8,3
22.5	25	33.3	0.99	32.3	11.34	32.6	25	50	0.99	40.1	12.21	40.3							50	50,0	1,98	45,6	23,55	45,6
27.5	25	33.3	1.48	48.2	17.11	49.2	25	50	1.48	59.9	18.12	59.7							50	33,3	2,96	45,2	35,23	46,1
sum	75	100	3.07	100	34.76	100	50	100	2.47	100	30.33	100							125	100	5,54	100	65,09	100
	Thinning weight				Dg=22.8 cm		Thinning weight				Dg=25.1 cm								Thinning weight					
	N=9.8%				Hg=23.8 m		N=6.6%				Hg=26.8 m								N= 16.4%					
	G=9.4%						G=7.5%												G= 16.9%					
	per: V=9.3%						per: V=8.1%												per: V= 17.3%					

Total volume is from 243.17 to 431.56 m^3/ha, average 375.39 m^3/ha. Current volume increment is from 5.5 to 8.3 m^3/ha, or average 7.2 m^3/ha. Hungarian oak percentage in total volume is 51.9%, it is on average 194.92 m3/ha, and it ranges from 121.36 to 254.22 m/ha.

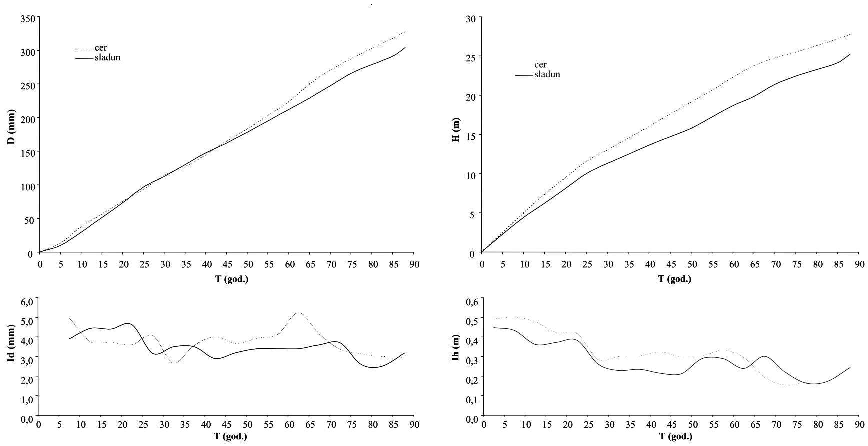
Turkey oak volume is from 113.04 to 245.12 m^3/ha or average 173.16 m^3/ha, which is 46.1% of the total stand volume. The percentage of hornbeam in total volume ranges from 1.1 to 3.6%, average volume is 7.31 m^3/ha (4.38 – 9.5 m^3/ha). Increment percentage ranges from 1.76 to 2.26%.

The above study results agree with the results of the research in Hungarian oak and Turkey oak forests in this area reported by Stojanović (1988).

3.2. Tree development

The analysis was performed on three trees of 20% largest trees in the stand, individually for Turkey oak and Hungarian oak.

Diagram 2. a) Hungarian oak and Turkey oak diameter growth and current diameter increment b) Hungarian oak and Turkey oak height growth and current height increment



The curve of Turkey oak total diameter growth shows a more intensive development in the first 30 years, which is the basic characteristic of the trees of coppice origin. The diameter at the highest Turkey oak common age reaches 31.1 to 34.4 cm, average 32.7 cm. The culmination of current diameter increment is attained at the ages of 5-10 (10-30), and the culmination value is on average about 5.0 mm (4.7 to 7.2 mm). The development of current diameter increment points to the existence of several culminations; the last one occurs at the age of about 65 (60-65), and is on average about 5.2 mm (5.1 – 5.5 mm).

In the final analysed age, Hungarian oak diameter is 30.4 cm (27.5 – 32.1 cm). The first culmination of current diameter increment occurred at the age of 10-25, and it is on average 4.6 mm (4.6 to 6.6 mm). Just as in the case of Turkey oak, there are several culminations, of which the last occurs at the ages of 70-75 and is on average about 3.7 mm, which is for about 20% less than the first culmination value. In the area of Kraljevo, in the Hungarian oak and Turkey oak coppice forest on pseudogleyed luvisol over serpentinite and diorite, Stojanović *et al.* (2006) found somewhat lower values than in this study – 3.8 mm, while the time of culmination was identical.

Turkey oak height at the highest common age was from 26.6 to 28.4 m, or average 27.7 m. Current height increment culminated very early, and the culmination occurred at the age of about ten years (5-10). Average culmination value was 0.50 m (0.48 to 0.79 m) after which it declined permanently till thirty years of age. This is followed by the growth with minor oscillations, and there are several maxima of which the last one is between 55 and 60 years of age, with the value considerably lower than that of the first culmination, average 0.33 m.

Hungarian oak current height increment culminates on average at about the age of 5 years (individually 5-25), and amounts to 0.45 m (0.50 to 0.66 m). After that, the increment declines gradually, but after the age of fifty years, it grows again and the last culmination occurs between 65-70 years of age, average value 0.30 m. The occurrence of several culminations is the consequence of thinning, which resulted in the increase of increment of the remaining trees.

3.3. Stand quality

Stand quality, expressed by the percentage of trees of the definite morphological, biological and technical characteristics, is one of basic parameters for the determination of the stand degradation degree.

The percentage of trees in the first biological position is 54.9%, the second - 34.1%, and the third - 11%. In the stand, there are a much greater number of suppressed Hungarian oaks. They have been more harvested because of better quality wood, so the number of trees is almost equal in the first and the second biological positions.

Table 2. Percentage of trees per biological position, stem and crown quality

	Biological position	Stem quality	Crown quality
	Hungarian oak		
good	41.2	7.8	11.8
medium	43.1	29.4	27.5
poor	15.7	62.8	60.8
	Turkey oak		
good	77.4	51.6	38.7
medium	19.4	32.3	45.2
poor	3.2	16.1	16.1
	Total		
good	54.9	24.4	22.0
medium	34.1	30.5	34.1
poor	11.0	45.1	43.9

About 20% of the trees in the stand have good stems and crowns, and somewhat more than 30% have medium quality crowns and stems. Hungarian oak trees are of considerably poorer quality than Turkey oaks, and most often they have curved stems, partly decayed, with water shoots and with small crowns. The most frequent defect of Turkey oak is frost shake, its crown quality is mainly good, and only 16.1% of trees has poor crowns.

Based on the above characteristics, it could be concluded that the stand has from 1/3 to 2/3 of good-quality trees, so after Krstić (2002), the stand quality can be categorised as the stand of medium quality.

3.4. Proposal of silvicultural measures and selection of silvicultural operations

Stand characteristics represent the group of the most important factors for the determination of the degradation degree and the selection of the optimal methods of forest reclamation. Concrete parameters are: stand origin, composition and mixture, stand development phase, stand quality, stand structure, stand health and the percentage of principal tree species (Krstić, Stojanović, 1996). The study stand is situated on a good and conserved site, and has a sufficient number of good-quality trees, so the final silvicultural goal should be its conversion into the high silvicultural form, by the conversion in combination with restitution.

As this is a forest which is in direct vicinity of the Monastery Bogovađa, and as such forests should be managed as special purpose forests, its regeneration must be seriously undertaken. As this is an even-aged forest, aged 90-100 years, to avoid the formation of a young stand over a large area as the result of the regeneration, and bearing in mind the forest function, it is necessary to establish an all-aged stand. This can be achieved by the combined forms of natural regeneration, where in the best parts of the stand the regeneration should start immediately, while on the poorest parts it should be postponed for later periods. In this way, several age groups would be established within the forest, which would result in the all-age structure.

In the study stand, altogether 200 to 225 best-quality trees per ha were selected per sample plots (average 213 per ha). Their percentage per tree number is from 25.3 to 30.8%, i.e. per volume 47.4 to 67.0%. In the selection, a greater number of Hungarian oaks was selected, so as to maintain the mixture ratio in the future stand in favour of Hungarian oak. The percentage of Hungarian oaks in the future trees ranges from 50 to 66.7%. Mean diameter of future Turkey oaks is 34.1 cm, and that of Hungarian oaks is 29.0 cm, and they are considerably larger than mean stand diameters, which points to the selection of the highest and the largest diameter trees, selected in the commercial part of the stand. The quality of the trees is satisfactory, although Hungarian oak trees are lower quality than Turkey oaks, which means that artificial regeneration should be applied in combination with natural regeneration.

During the thinning, all trees of poor health were removed, the trees of poor phenotype characteristics, as well as the competitors to future trees. It was a mixed selection thinning, of light to moderate weight, amounting to 7.7 to 20% per tree number, i.e. 7.1 to 18.8% per volume. Hornbeam trees have not been removed to date, because they have a positive role in the stand for the time being. As these trees still do not yield seed, they are not dangerous to the stand, for the moment.

The main silvicultural goal is to convert these forests into high forests by conversion in combination with restitution.

4. CONCLUSION

Based on the in-depth study of the coppice stand of Hungarian oak and Turkey oak, aged 90 years, which is typologically defined as: coppice forest of Hungarian oak and Turkey oak with hornbeam (*Carpino betuli-Quercetum farnetto-cerris*) on deep lessivé soil with the elements of pseudogleying, it was concluded that:

Total number of trees in the stand ranges from 650 to 875 per ha, or average 763 per ha; Percentage of Hungarian oaks per tree number is 41.8%, Turkey oak 25.4% and hornbeam 32.8%.Total basal area in the stand is from 21.51 m^2/ha to 37.84 m^2/ha, or average 32.76 m2/ha. Total volume ranges from 243.17 to 431.56 m3/ha, average 375.39 m^3/ha; Current volume increment is 5.5 to 8.3 m^3/ha, or average 7.2 m^3/ha; increment percentage ranges from 1.76 to 2.26%.

Based on the analysis of diameter and height increment, it is observed that Hungarian oak lags behind Turkey oak in diameter growth after the age of fifty years, and in height growth after the age of twenty years. Their courses of increment are similar, but the values of both increments of Hungarian oak throughout the life cycle are lower, which proves the fact that Hungarian oak is a biologically weaker species in such a mixture, because of its lower growth vigour. The occurrence of several culminations is the consequence of thinning, which caused the increased increment of the remaining trees.

Based on the analysis of the biological position, stem quality, and crown quality, it was concluded that it is the stand of medium quality. Turkey oak stem and crown quality is considerably higher than that of Hungarian oak, which is the consequence of the removal of the best Hungarian oaks from the stand in the past, because of the higher wood quality.

Based on the present state, the study stand can be characterised as a good coppice forest on a good site. Consequently, the most justified silvicultural treatment is the conversion of the silvicultural form, i.e. the conversion into high mixed forest, in combination with restitution.

Before the beginning of regeneration by tending, the stand should be prepared for the regeneration, the composition should be regulated, the trees with poorer phenotype characteristics, diseased and lower vitality trees should be removed. Altogether 213 best-quality trees per ha were selected, and the tendency was to select a greater number of Hungarian oaks than Turkey oaks, so as to maintain the mixture ratio in favour of Hungarian oak trees in future. The quality is satisfactory, although Hungarian oak trees are poorer than Turkey oaks; therefore it is necessary to combine natural and artificial regeneration. Thinning weight ranged about 20% per tree number, and also per other elements, so the thinning weight was light to moderate. Regeneration felling should be performed in the year of full seed crop in the best parts of the stand, but it should be postponed in the poorest parts, to create more age groups in the forest and to achieve some degree of all-agedness. All the above silvicultural measures are undertaken in the aim of stand preparation for regeneration and its conversion into the higher silvicultural form, which is the final silvicultural goal.

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GROUND VEGETATION AS THE SITE INDICATOR IN HIGH BEECH STANDS IN THE AREA OF SEVERNI KUČAJ

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Abstract: *The presence of ground vegetation as indicators of site conditions was researched in three beech stands in the area of Severni Kučaj in East Serbia. The plants of the ground flora were registered by Braun-Blanquet's method: the species which indicate soil acidity, humus type, and the species which disturb the natural regeneration of these forests. In the stand 33a, with the prevailing limestones, the most represented species are neutrophilous species. Acidophilous and basiphilous species are present only in individual releves, and they occur exclusively as individuals. Of the humus indicators, the species which indicate mull humus have the highest percentage, which points to the favourable conditions of the organic matter transformation and the fast nutrient cycling in the ecosystem. The species which disturb natural regeneration are the Rubus species. In the stands 42a and 42b, due to an excessive weediness by Rubus species, the other ground flora is scarce. Still, the neutrophilous conditions of soil acidity, as well as the fast organic matter transformation, were assessed based on the present plants.*

Key words: site, ground flora, indicator species

1. INTRODUCTION

Beech is the most widespread species of forest trees in Serbia. In the area of Severni Kučaj, which is an explicitly broadleaf area, the most represented tree species is also beech. Its percentage in the total forested area is 70%, in total volume 76.2%, and in volume increment 67.8% (Medarević *et al.*, 2003).

In the study area, beech forests grow in different ecological conditions. Some of the most significant site conditions which affect the production and quality characteristics of beech stands are soil conditions. General site conditions can very often be identified by the ground flora plants. Ground vegetation of the study stands was studied as an indicator of the selected site conditions in the aim of assessing the site conditions more efficiently and completely.

2. STUDY AREA AND METHOD

Two study areas with altogether three stands were established in the forest area "Severni Kučaj", in Management Units "Majdan-Kučajna" and "Crni Vrh" within the project "Method of assessment of quality and assortment structure of beech high stands in Serbia".

The first stand is in MU "Majdan-Kučajna", compartment 33a, in the submontane beech forest *Fagetum moesiace submontanum*, at the average altitude of 446 m (406-513 m), slope 20.6° (7°-28.0°) and exposure West-Northwest.

The second study area is in MU "Crni Vrh", and it includes two stands. One stand is in compartment 42a, in montane beech forest *Fagetum moesiace montanum.* Its average altitude is 956 m (929-982 m), slope 10.8° (6°-17.0°), and exposure Northwest. The other stand is in

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compartment 42b, also in montane beech forest *Fagetum moesiace montanum*, where the average altitude is 1000.2 m (984-1020 m), slope 11.1° (7°-15°), exposure Northwest.

The method is based on the "Method of taxation data collection and processing for the study of quality and assortment structure of beech high stands in Serbia" by Koprivica *et al.* (2006). The general stand and site data are collected on sample plots designed in the form of circles, size 500 m2 (radius 12.62 m), distributed in the square grid network, spacing 100 m, so that one circle represents 1 ha of the study stand.

There are altogether 50 circles in all three stands. On each circle, the soil type was determined and the samples for laboratory analysis were taken from the representative profiles. The ground flora plants which indicate the site conditions were recorded. The combined abundance, degree of coverage and sociability were assessed for each species according to Braun-Blanquet's method. In this aim, 3 groups of plants were selected, which represent significant ground and shrub flora in beech forests. The first group are the plants which are indicators of soil acidity, including acidophilic, neutrophilic and basophilic species. The second group includes the plants which indicate the type of humus, i.e. the indicators of accelerated decomposition of organic matter and the generation of mull humus, and the indicators of slow decomposition of organic matter and the generation of moder to morr humus. In addition to the above species, a special group consists of silviculturally significant species which, by their higher abundance, coverage and sociability, can jeopardize natural regeneration.

3. RESULTS

3.1 Soil conditions

The stand in MU "Majdan-Kučajna" is characterised by very different conditions for beech growth and development. The bedrock consists of limestones, red sandstones and quartz sandstones.

The illimerised soils (luvisols) occur in the flattened parts of the stand on limestone bedrocks. Black soils are developed in the stand parts on limestones, on steep slopes. Brown limestone soils are only fragmentarily represented in individual parts of the stand, but outside the study sample plots. Acid brown soils are formed in the stand part over red and quartz sandstones.

Colluvial black soils are formed by colluvial diluvial processes at individual places on limestone bedrock. In the solum, they contain also the material of siliceous origin, which is brought from the higher elevations with sandstone bedrock.

Soil conditions in MU " Crni Vrh", in both study stands, are far more uniform. In both study stands, the soil is colluvial dystric ranker on andesite. In the lower part of the profile, and particularly in the stand 42b, there are signs of brownisation.

3.2 Analysis of indicators of site conditions

The floristic composition of the ground flora indicator species enables a more in-depth analysis of site conditions. These species indicate primarily the pedological conditions. Along with these species, we also selected the species which have silvicultural significance as the indicators of the previous silvicultural measures and of the effects of the extreme abiotic and biotic conditions.

Due to the high percentage of blackberry (*Rubus hirtus*) causing the openings in the canopy due to the higher effect of the extreme climate factors, the indicators of acidity and humus type in the stands of montane beech forest (42a and 42b) have low abundance, coverage and sociability, so their capacity of indicating the site conditions is lower.

3.2.1 Analysis of the indicators of soil acidity

Throughout the stand of the submontane beech forest *Fagetum moesiace submontanum* (33a), the neutrophilic ground flora species are absolutely dominant. The species *Cardamine bulbifera* has the highest degree of constancy (IV) in the stand and therefore, in the syntaxonomic sense, it defines this community more closely. This species is present on 78.26% of the sample plots. The second significant species is also a neutrophilic species *Mercurialis perennis*, which is just as the previous one, a very frequent species in submontane beech forests on neutral to weak acid soils. Other neutrophilic species are represented by a low degree of constancy, as well as by a low combined abundance, coverage and sociability. Among them, the species *Asperula odorata*, also a very frequent companion of submontane beech forests, occurs in a lower number of plant community relevés, but in larger groups. The acidophilic species (*Polistichum lonchitis, Pteridium aquilinum)* and basophilic species (*Hepatica triloba, Geum urbanum)* occur only in individual relevés, i.e. exclusively individually. Their occurrence is conditioned by some microsite conditions and they do not have a special significance in this plant community.

In the montane beech forest *Fagetum moesiace montanum* (stand 42a and 42b), there occur only the species which indicate weak acid to neutral reaction, but because of excessive weediness, their degree of constancy in the stands is low and they occur mainly as individuals.

The analysis of the presence of acidity indicators per soil types (Table 1) shows that, in the submontane beech forest *Fagetum moesiace submontanum* (stand 33a), and on the soil series on limestones (black soil - typical, colluvial black soil, lessivé soil on limestone), and on the soils on siliceous parent rock (acid brown soil on red and quartz sandstone), *Cardamine bulbifera* has the highest degree of constancy, followed by the species *Mercurialis perennis*. The individual presence of acidophilic and basophilic species, only on individual sample plots on typical black soil and luvisol on limestones, is only of micro-local character and it does not indicate the soil characteristics, even on the sample plots where they occur individually. The typical black soil on limestone and acid brown soil on quartz sandstone, due to their lower percentage, are represented only by one sample plot each, so their floristic composition is not representative.

In contrast to the above stand, in both stands of the montane beech forest *Fagetum moesiace montanum* (42a and 42b) which grow on dystric ranker on andesite, the neutrophilic species *Cardamine bulbifera* and *Asperula odorata* were not identified, while *Mercurialis perennis* occurs only in one relevé, i.e. individually. *Allium ursinum* has a more significant abundance, degree of coverage and sociability in the stand 42a, but only in one relevé. If these plants are considered as exclusive neutrophilic, then their absence can be related to a lower saturation of the adsorptive complex with base cations in dystric ranker, to colder climate (altitude 950-1000 m) and excessive weediness.

Based on soil characteristics in Table 1, it can be concluded that the registered indicator species can produce only a general idea that these soils are acid to neutral soils, while the precise value of soil characteristics can be obtained only based on the soil analysis.

3.2.2 Analysis of the indicators of humus type

In the submontane beech forest *Fagetum moesiace submontanum* (stand 33a), the indicators of weak acid to neutral reaction, such as *Cardamine bulbifera* and *Mercurialis perenis*, mainly indicate the favourable conditions of the organic matter transformation (Table 2). In addition to the above two species as indicators of ripe (mull) humus, *Arum maculatum* occurs with a high degree of constancy. The species *Asperula odorata,* which is known as the indicator of the most favourable conditions of the organic matter transformation, has a low degree of constancy in this stand, but it forms major facieses, so it is classified as high coverage. Among the species which indicate somewhat poorer conditions of the organic matter transformation (moder humus), *Polistichum lonchitis* occurs individually on 8.70 % of the study area.

Table 1: The indicators of acidity per soil types

Ground flora species	Degree of constancy	Number of sample plots	Frequency (%)	Abundance -degree of coverage and sociability	Soil characteristics			
					Depth (cm)	pH	V (%)	C/N
STAND 33a								
Black soil-typical		1	4.35		18	4.9	78.93	8.89
Cardamine bulbifera		1	100.00	2.1				
Nephrodium filix femina		1	100.00	+.1				
Pteridium aquilinum		1	100.00	+.1				
Colluvial black soil		5	21.74		50	4.9	42.48	7.89
Cardamine bulbifera	III	3	60.00	1.1				
Mercurialis perenis	III	2	40.00	1.3				
		1	20.00	+.1				
Geranium robertianum	II	1	20.00	1.3				
		1	20.00	+.2				
Nephrodium filix femina	I	1	20.00	+.1				
Luvisol		10	43.48		100	3.4	20.33	8.89
Cardamine bulbifera	V	6	60.00	2.1				
		2	20.00	+.1				
		1	10.00	1.1				
Mercurialis perenis	III	3	30.00	1.3				
		1	10.00	1.1				
		1	10.00	+.1				
Nephrodium filix mas	I	2	20.00	+.1				
Polystichum lonchitis	I	2	20.00	+.1				
Asperula odorata	I	1	10.00	2.4.				
		1	10.00	1.3				
Geranium robertianum	I	1	10.00	2.3				
		1	10.00	+.1				
Hepatica triloba	I	1	10.00	1.2				
Nephrodium filix femina	I	1	10.00	+.2				
		1	10.00	+.1				
Geum urbanum	I	1	10.00	+.1				
Acid brown soil		6	26.09		75	3.6	36.75	9.17
Cardamine bulbifera	IV	4	66.67	1.1				
Mercurialis perenis	III	3	50.00	1.3				
Geranium robertianum	II	2	33.33	+.1				
Asperula odorata	I	1	16.67	1.3				
Nephrodium filix mas	I	1	16.67	+.1				
Acid brown soil		1	4.35		80	3.4	11.27	8.97
Cardamine bulbifera		1	100.00	1.1				
STAND 42a								
Dystric ranker		17	100.00		60	4.1	11.74	8.43
Nephrodium filix mas	I	2	11.76	+.1				
Allium ursinum	I	1	5.88	2.3				
Nephrodium filix femina	I	1	5.88	1.2				
Mercurialis perenis	I	1	5.88	+.1				
Geranium robertianum	I	1	5.88	+.1				
No indicator		16	94.12					
STAND 42b								
Dystric ranker		10	100.00		60	4.0	16.1	9.42
Nephrodium filix mas	I	1	10.00	+.1				
Nephrodium filix femina	I	1	10.00	+.1				
No indicator		8	80.00					

Table 2: The indicators of humus type per soil types

Ground flora species	Degree of constancy	Number of sample plots	Frequency (%)	Abundance, degree of coverage and sociability	Soil characteristics			
					Depth (cm)	pH	V (%)	C/N
STAND 33a								
Black soil-typical		1	4.35		18	4.9	78.93	8.89
Cardamine bulbifera		1	100.0	2.1				
Arum maculatum		1	100.00	+.1				
Colluvial black soil		5	21.74		50	4.9	42.48	7.89
Mercurialis perenis	V	4	80.00	1.3				
		1	20.00	+.1				
Cardamine bulbifera	III	2	40.00	1.1				
		1	20.00	+.1				
Arum maculatum	III	2	40.00	1.1				
		1	20.00	+.1				
Luvisol on limestones		10	43.48		100	3.4	20.33	8.89
Cardamine bulbifera	V	6	60.00	2.1				
		2	20.00	+.1				
		1	10.00	1.1				
Arum maculatum	IV	6	60.00	+.1				
		2	20.00	1.1				
Mercurialis perenis	III	4	40.00	1.3				
		1	10.00	1.1				
		1	10.00	+.1				
Festuca drymeia	II	1	10.00	1.2				
		1	10.00	+.2				
		1	10.00	+.1				
Polystichum lonchitis	I	2	20.00	+.1				
Asperula odorata	I	1	10.00	2.4				
Acid brown soil on red sandstone		6	26.09		75	3.6	36.75	9.17
Cardamine bulbifera	IV	4	66.67	1.1				
Arum maculatum	IV	4	66.67	+.1				
Mercurialis perenis	III	3	50.00	1.3				
Asperula odorata	I	1	16.67	1.3				
Acid brown soil on quartz sandstone		1	4.35		80	3.4	11.27	8.97
Cardamine bulbifera		1	100.0	1.1				
STAND 42a								
Dystric ranker		17	100.0		60	4.1	11.74	8.43
Mercurialis perenis	I	1	5.88	+.1				
No indicator		16	94.12					
STAND 42b								
Dystric ranker		10	100.0		60	4.0	16.1	9.42
No indicator		10	100.0					

In the montane beech forest *Fagetum moesiace montanum* (stand 42a and 42b), because of the colder climate (950-1000 m), the general soil forming conditions are slower and also the organic matter transformation. For this reason the species such as *Cardamine bulbifera* and *Asperula odorata* are absent, and *Mercurialis perenis* occurs individually.

In the submontane beech forest *Fagetum moesiace submontanum* (stand 33a), the above species which indicate the mild mull humus have a high degree of constancy on all soil types. Only on luvisol on limestones, the individual presence of the species *Polistichum lonchitis* indicates somewhat poorer conditions of the organic matter transformation. The thickness of the humus-accumulation horizon of luvisol is small, which indicates the fast decomposition of the organic matter. The occurrence of *Polistichum lonchitis* on luvisol is the result of an acid reaction.

The soil characteristics indicate that luvisol, compared to the typical black soil and colluvial black soil, and even to acid brown soil on red sandstone, in humus accumulation horizon, has a lower degree of base saturation of the adsorptive complex, which is evidently indicated by the above fern species. However, the humus horizon in luvisol has a very small thickness. In the eluvial horizon, the degree of base saturation is lower, and that is why the species *Polistichum lonchitis* is found on this soil.

In the montane beech forest *Fagetum moesiace montanum* (stand 42a and 42b), because of the colder climate, the processes of the organic matter transformation are slower, so the indicators of mull humus formation are absent. However, the indicators of the type of humus on this site, because of the excessive weediness, could not be sufficiently exposed.

3.2.3 Species which disturb natural regeneration

The species which disturb natural regeneration are practically the weeds, whose occurrence indicates the previous silvicultural measures in the stands, as well as the effect of the extreme abiotic and biotic factors. Among the species which could endanger the natural regeneration in the submontane beech forest *Fagetum moesiace submontanum* (stand 33a), blackberry *Rubus hirtus* has the highest degree of constancy. However, only on about 30 % of sample plots, its abundance, degree of coverage and sociability are so high that it could endanger natural regeneration. Other species in the stand have a low degree of constancy and they occur mainly individually with a very low coverage that has no practical significance for stand regeneration

Table 3. Species which disturb natural regeneration per the degree of constancy

Ground flora species	Degree of constancy
STAND 33a	
Rubus hirtus	V
Sambucus nigra	II
Urtica dioica	I
Atropa belladona	I
Pteridium aquilinum	I
Crategus monogina	I
STAND 42a	
Rubus hirtus	V
Atropa belladona	I
Urtica dioica	I
Sambucus nigra	I
STAND 42b	
Rubus hirtus	V
Sambucus nigra	I

In the montane beech forest *Fagetum moesiace montanum* (stand 42a and 42b), primarily because of the frequent canopy breaking, due to high effects of the extreme climate conditions (ice, snow and wind), blackberry covers almost the entire area with a high abundance, coverage and sociability, so practically in both stands it is a weed which seriously endangers the natural regeneration potential. It is so much represented that other weed species have no practical significance for stand regeneration. The presence of blackberry in these stands reduces the percentage of other indicator species.

4. CONCLUSIONS

- In all three study stands, the ground flora species which indicate a neutral to weak acid reaction (neutrophilic species) are absolutely dominant per the degree of constancy, combined abundance, degree of coverage and sociability;
- Acidophilic species have very low abundance in all stands and their occurrence is mainly conditioned by microsite conditions. However, it was noted that they were mainly conditioned by the low saturation of the adsorptive complex with base cations. This conclusion should be confirmed by further research;
- The individual presence of basophilic species is also conditioned by microsite conditions and it does not have a major significance;
- The ground flora species which indicate neutral to weak acid reaction, with some more species, indicate also the favourable conditions for the transformation of the organic matter;
- In contrast to the submontane beech forest *Fagetum moesiace submontanum*, in montane beech forest *Fagetum moesiace montanum*, which is at the higher altitude, where the climate is colder, the soil formation processes are slower, and so is the transformation of organic matter. Such conditions, as well as the excessive weediness at this site, contributed to the absence of the indicators of the accelerated transformation of organic matter and the generation of mild mull humus;
- It can be concluded that indicator species can give a general idea on a site, while the precise value of the soil characteristics can only be obtained based on the soil analysis;
- The excessive weediness is an indicator of silvicultural measures operated in the stands, as well as of the effect of the extreme abiotic and biotic factors. It reduces the presence of other indicator species.

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THE STATE AND PROPOSAL OF SILVICULTURAL OPERATIONS IN THE ARTIFICIALLY ESTABLISHED SPRUCE STAND ON THE SITE OF MONTANE BEECH FOREST IN THE AREA OF ČEMERNIK

Tatjana ĆIRKOVIĆ[1]

Abstract: *In a part of the coppice beech forest in the area of Čemernik, the beech of vegetative origin was restructured by substitution with coniferous species. The species with which beech was most often substituted is spruce. For this reason, we researched the artificial stand of spruce, 36-years old, established on the site of montane beech forest in this region. This paper presents the results of the detailed research of the site characteristics and the stand state. The proposal of the optimal silvicultural operations in this artificial stand is based on the study results. Considering the current state and silvicultural demands, the proposed silvicultural measure is mixed selection thinning of moderate intensity. A "cautious" thinning is proposed because of a considerable form quotient. As the trees are liable to wind throw and snow break, the stand instability would be increased by a more intensive thinning of the upper layer, or by a greater canopy opening.*

Key words: artificially established stands, spruce, stand structure, selection thinning

1. PROBLEM AND TASK

The afforestation and the establishment of conifer plantations in Serbia were particularly intensive in the last decades of the 20th century, so today they cover 155.135 ha (6,6% of the total growing stock in Serbia). The area under these plantations and artificially established stands managed by SE "Srbijašume" amounts to 99.050 ha (12,8% of the total area under forests in this enterprise). Their age is from 1 to 80 years; plantations above the age of 20 years (the period when tending i.e. thinning should start) cover the area of 43.092 ha, i.e. 43,5%, and the plantations below 20 years occupy 55.958 ha, or 56,5% of the total area.

The most frequently established plantations are Austrian pine (*Pinus nigra* Arn.), spruce (*Picea abies* Karst.) and Scots pine (*Pinus silvestris* L.). Austrian pine plantations and artificial stands cover 52.585 ha, or 53,1% of the area, of which below 20 years – 48,3%, and above 20 years – 51,7% of the area under this species. Plantations and artificially established stands of spruce occupy 30.622 ha (30,9%), the stands below 20 years - as much as 70,8%, and the older stands occupy 29,2% of the area. The area under Scots pine is 9.860 ha, which is 10,0% of the total area of plantations and artificially established stands. Below 20 years – 58,0%, and older stands – 42,0%. Other conifers (fir, Douglas-fir, Weymouth pine, larch and others) occupy 6,0% of the entire area under conifer plantations and artificial stands (Medarević, *et al.*, 2002).

The study of plantations and artificially established stands of conifers, their internal structure, environmental conditions, tending measures, etc. in Serbia was reported by Stojanović

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(1989-1990), Stojanović et Banković (1981), Krstić (1998), Stojanović et Krstić (1984), Jovanović et Stojanović (1982), Vučković et Stamenković (1991), Koprivica et al. (1998), Bobinac (2004), Ćirković (2006), and others.

The area of Čemernik and Ostrozub has also been intensively afforested in the last decades, so the total area under coniferous plantations and artificially established stands today amounts to 3.052,32 ha, which is 23,7% of the total area, i.e. 26,2% of the forested area, which is considerably higher than the average values in Serbia. A small part of the plantations was established in the belt of oak forests (Hungarian oak and Turkey oak), at the site of the montane beech forest, but the greatest part was established in the belt of montane forest beech. Thus in MU "Kačer – Zeleničje" in the belt of montane beech forest, 92,1% of the total area is under spruce, 89,2% of the total area is under Scots pine, 69,9% of total area is under Austrian pine, and all plantations and artificial stands of Japanese larch are established at the altitudes above 1.000 m. In the coppice beech forests, the reconstruction was mainly performed by substitution, i.e. by replacing the beech of coppice origin by coniferous species. The most represented species is spruce, which occupies 72,9% of the area under conifers.

Because of the significant percentage of spruce plantations and artificial stands, which are mainly silviculturally neglected, their state should be studied and improved by the adequate silvicultural measures. The subject of this study is the artificial stand of spruce established at the site of montane beech forest in the area of Čemernik, MU "Kačer – Zeleničje". The main task of the paper is:

- study the environmental conditions in the artificially established stand,
- research the stand state, stand quality and the development of future trees,
- based on the state and previous research, present the proposal of silvicultural operations in the artificially established stand.

2. STUDY AREA AND METHOD

The researched artificially established spruce stand, whose age at the time of field study and data collection (2000) was 36 years, is situated in MU "Kačer – Zeleničje", compartment 24 c, at the altitude of 1.260 to 1.300 m, North to Northeast exposure and mildly flattened terrain (slope 0 to 3°).

A series of sample plots were established in the stand for the phytocoenological research by Cvjetićanin during 2002 and for soil research by Knežević during 2001 and 2002. The stand was established on the site of montane beech forest (*Fagetum moesiacae montanum* B. Jov. 1953). The bedrock consists of schists, and the soil is leached acid brown soil. The canopy is very dense (0,9), the ground flora is very poor in species, and they are only individually represented.

The climate and vegetation characteristics of Čemernik area were studied by Krstić et Ćirković (2005). According to Lang's bioclimate classification, the climate is humid, and the forests are in their biological optimum. The average annual temperature is 4,8 °C, during the vegetation growth period 10,2 °C. The average annual precipitation is 843 mm, i.e. 454 mm during the vegetation period (53,9% of the annual value).

The measurement and collection of taxation elements on permanent sample plots, as well as data processing, was performed by usual methods. The biological position of all trees was assessed, as well as the quality of stems and crowns. For the dendrometric analysis of the diameter and height increment, three mean future trees were felled, which belong to the group of 20% of the largest trees in the stand.

3. RESULTS

3.1. Stand state and structure

The basic data on the study stand are presented in Table 1 and Diagram 1.

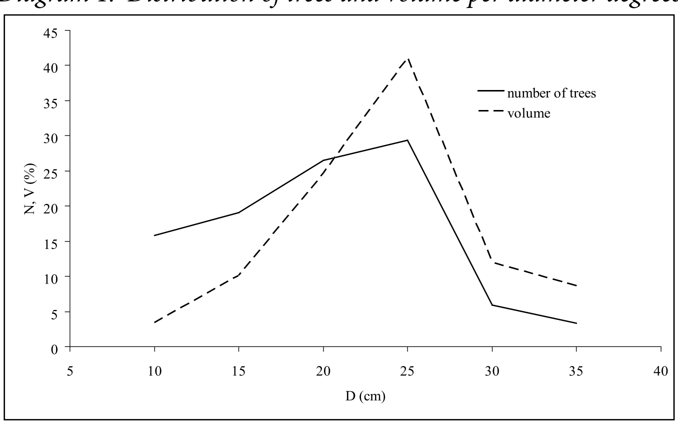
The number of trees in artificially established spruce stand is averagely 1.324 per ha, from 1.119 to 1.484. All the trees are distributed in diameter classes from 10 to 35 cm (variation width 25 cm), with the maximum in the diameter class of 25 cm (Diagram 1). About 60% of trees are classified in three diameter classes about the maximum percentage – 20, 25 and 30 cm.

Both the entire stand and the trees, classified by the biological position in the stand, are characterised by the binomial distribution of trees. The percentage of dominant trees is 62,0%, diameter degrees 15 – 35 cm. Their mean diameter is 24,1 cm and it belongs to the diameter degree of the greatest number of these trees. The percentage of codominant trees, with the mean diameter at breast height 16,3 cm, is 22,0%.These trees belong to diameter degrees 10 – 30 cm.The smallest-size trees, suppressed trees account for 16.0% (mean diameter 11.6 cm). The left branch of the distribution line of these trees is reduced because of the dying of the thinnest trees.

The number of trees is variable and in artificially established stands it depends on planting density, among other influential factors. Thus in the spruce stand of artificial origin established on the site of montane beech (*Fagetum montanum silicicolum*), Vučković, M. *et al.* (1990) report about 3.000 trees per ha 35-years old, after the schematic thinning. Stojanović et Krstić (1984) report that, at planting density of 10,000 seedling per ha, on the site of montane beech forest on Magleš, in artificial spruce stand there were 2.840 trees per ha at the age of 32 years, and 2.330 after 5 years (at the age of 37 years), without any thinning or any silvicultural interventions.

Planting density in the study stand was 2.500 seedlings per ha, so the number of trees is lower than that in the above reports by other authors. Mean stand diameter per basal area is 21,0 cm, and the height of the mean stand trees is 19,3 m.

Diagram 1. Distribution of trees and volume per diameter degrees



The high values of the diameters at breast height and heights are the consequence of the high production potential of the site at which this artificial stand was established. The sum of basal areas ranges from 33,19 to 51,67 $m^2 \cdot ha^{-1}$, average 45,99 $m^2 \cdot ha^{-1}$. Wood volume is on average 317,41 $m^3 \cdot ha^{-1}$, from 232,40 to 356,82 $m^3 \cdot ha^{-1}$. Volume structure is, just like the structure per basal area, represented by bell-shaped line. The maximum percentage of volume is in the diameter degree of 25 cm, which also has the maximal number of trees. Volume increment of this spruce stand is from 10,69 to 15,87 m3$\cdot ha^{-1}$, average 14,06 $m^3 \cdot ha^{-1}$.

Table 1. **Basic data on the study stand**

<table>
<tr><td colspan="8">MU “Kačer – Zeleničje“</td><td colspan="7">Compartment 24 c</td><td colspan="6">Series IV</td></tr>
<tr><td colspan="8">Altitude 1.260-1.300 m</td><td colspan="7">Slope 0-3°</td><td colspan="6">Exposure N</td></tr>
<tr><td colspan="21">Artificially established spruce stand at the site of montane beech forest (Fagetum moesiacae montanum B. Jov. 1953) on leached acid brown soil on schists</td></tr>
<tr><td rowspan="3"></td><td colspan="8">INITIAL STATE</td><td colspan="6">FUTURE TREES</td><td colspan="6">MARKED TREES</td></tr>
<tr><td colspan="2">N</td><td colspan="2">G</td><td colspan="2">V</td><td>dg</td><td>hg</td><td colspan="2">N</td><td colspan="2">V</td><td>dg+</td><td>hg+</td><td colspan="2">N</td><td colspan="2">V</td><td>dg</td><td>hg</td></tr>
<tr><td></td><td>%</td><td>m2/ha</td><td>%</td><td>m3/ha</td><td>%</td><td>cm</td><td>m</td><td></td><td>%</td><td>m3/ha</td><td>%</td><td>cm</td><td>m</td><td></td><td>%</td><td>m3/ha</td><td>%</td><td>cm</td><td>m</td></tr>
<tr><td>10</td><td>210</td><td>15,9</td><td>1,66</td><td>3,6</td><td>10,92</td><td>3,4</td><td rowspan="6">21,0</td><td rowspan="6">19,3</td><td></td><td></td><td></td><td></td><td rowspan="6">27,3</td><td rowspan="6">21,0</td><td>96</td><td>34,4</td><td>4,99</td><td>9,4</td><td rowspan="6">18,7</td><td rowspan="6">18,4</td></tr>
<tr><td>15</td><td>252</td><td>19,0</td><td>4,46</td><td>9,7</td><td>32,00</td><td>10,1</td><td></td><td></td><td></td><td></td><td>47</td><td>16,8</td><td>5,97</td><td>11,3</td></tr>
<tr><td>20</td><td>351</td><td>26,5</td><td>11,02</td><td>24,0</td><td>78,27</td><td>24,7</td><td>27</td><td>9,8</td><td>6,03</td><td>5,6</td><td>46</td><td>16,5</td><td>10,26</td><td>19,4</td></tr>
<tr><td>25</td><td>389</td><td>29,4</td><td>19,10</td><td>41,5</td><td>130,32</td><td>41,1</td><td>154</td><td>56,1</td><td>51,70</td><td>47,4</td><td>80</td><td>28,7</td><td>26,80</td><td>50,6</td></tr>
<tr><td>30</td><td>78</td><td>5,9</td><td>5,51</td><td>12,0</td><td>38,22</td><td>12,0</td><td>55</td><td>20,1</td><td>27,08</td><td>24,8</td><td>10</td><td>3,6</td><td>4,90</td><td>9,3</td></tr>
<tr><td>35</td><td>44</td><td>3,3</td><td>4,23</td><td>9,2</td><td>27,68</td><td>8,7</td><td>39</td><td>14,0</td><td>24,25</td><td>22,2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Σ</td><td>1.324</td><td>100</td><td>45,99</td><td>100</td><td>317,41</td><td>100</td><td colspan="2">h/d=92</td><td>275</td><td>100</td><td>109,06</td><td>100</td><td colspan="2">h/d=77</td><td>279</td><td>100</td><td>52,92</td><td>100</td><td colspan="2">h/d=98</td></tr>
<tr><td rowspan="5"></td><td colspan="6">STATE AFTER FELLING</td><td colspan="2" rowspan="2">Stand age
36
years</td><td colspan="6">PERCENTAGE OF FUTURE TREES IN THE STAND</td><td colspan="6">THINNING INTENSITY</td></tr>
<tr><td colspan="2">1.045</td><td colspan="2">38,32</td><td colspan="2">26,49</td><td colspan="6">per N=20,8%</td><td colspan="6">per N=21,1%</td></tr>
<tr><td colspan="4" rowspan="3">iv = 14,06 m3/ha</td><td colspan="4" rowspan="3">piv = 4,43%</td><td colspan="6">per G=34,9%</td><td colspan="6">per G=16,7%</td></tr>
<tr><td colspan="6">per V=34,3%</td><td colspan="6">per V=16,7%</td></tr>
<tr><td colspan="6">per iv=32,3%</td><td colspan="6">per iv=17,1%</td></tr>
</table>

3.2. Diameter development of mean future trees

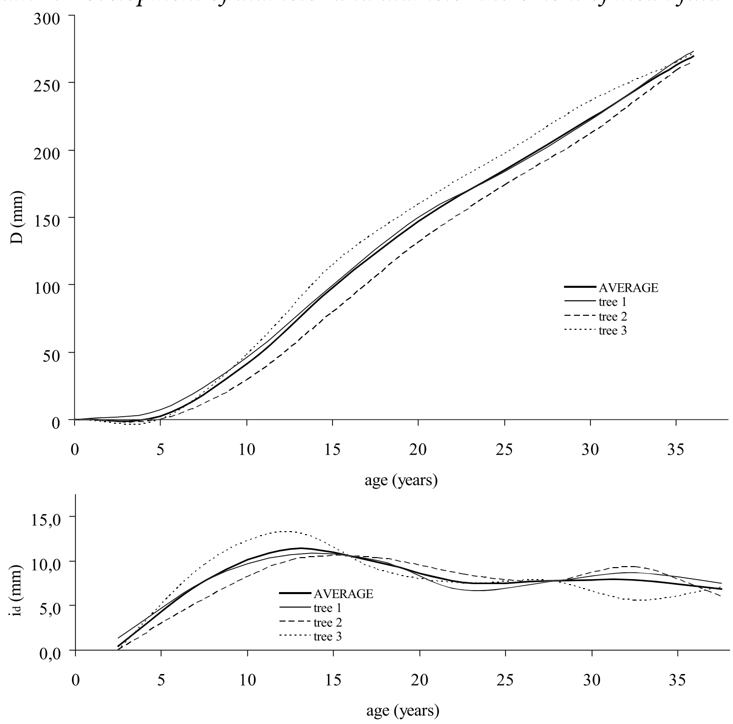
Diameter at breast height of the analysed trees (with bark) is from 27,1 to 28,1 cm, average 27,7 cm, and average bark thickness is 6,7 mm.

Current diameter increment culminates between the ages of ten and fifteen years, at the value of 11,37 mm. After the culmination, it decreases to the age of about twenty (twenty-five) years, and then gets the uniform course nearing about 8,0 mm (Diagram 1).

The average diameter increment reaches the maximum at the age of thirty-five with 7.51 mm.

The results of our research agree with the results reported by Bobinac (2004) on the culmination of diameter increment of spruce trees and the time of culmination in an artificially established spruce stand at the site *Fagetum moesiacae montanum* Jov. B. 1953 on Velika Brezovica (Južni Kučaj), as well as with the results reported by Koprivica *et al*. (1998) in artificially established spruce stands at the sites of high productivity in the area of Ivanjica, at the altitudes from 950 to 1.350 m, and also with the results reported by Stojanović et Krstić (1984) in artificial stands of spruce established at the site if montane beech forest on Magleš, etc. In the artificial spruce stands at the site of montane beech forest (*Fagetum montanum silicicolum*) at the altitude of 1.080 m in MU "Mučanj" Vučković *et al.* (1990) found the culmination of current diameter increment at the age of thirteen, amounting to 12,5 mm, and the average at the age of 38, amounting to 7,8 mm.

Diagram 2. Development of diameter and diameter increment of mean future trees



3.3. Height development of mean future trees

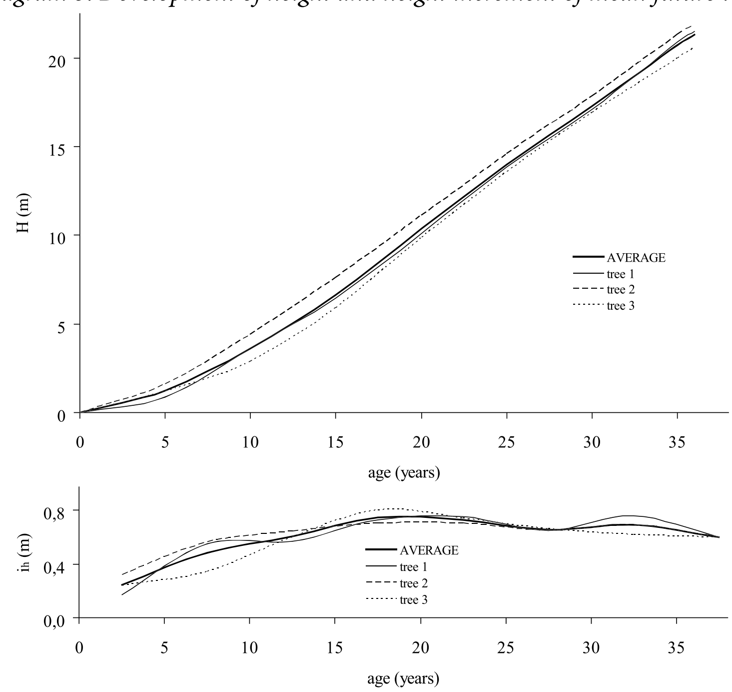
The average height of the analysed trees is 21,3 m, from 20,6 to 21,9 m.

Current height increment reaches the maximum at the age between 15 and 20 years, amounting to 0,74 m. After this, it decreases to the age of about 30 years, and then again starts increasing and reaches the second, lower culmination, between the ages of 30 and 35 years, when it amounts to 0,69 m (Diagram 3).

The average height increment at the final age of 36 years, in which its value is 0,53 m, has not yet culminated.

Just as in the case of the development of diameter and diameter increment, our results on height development agree with the results for artificially established spruce stands in similar environmental conditions at the site of montane beech forest, reported by Stojanović et Krstić (1984) on Magleš, Vučković et al. (1990) in MU "Mučanj", Koprivica et al. (1998) in the area of Ivanjica, Bobinac (2004) on Velika Brezovica, etc.

Diagram 3. Development of height and height increment of mean future trees



3.4. Stand quality

In addition to the classification according to their biological position in the stand, all trees are also classified according to their stem and crown quality – good I, medium II and poor III (Table 2).

Table 2. Differentiation of trees per biological position, stem and crown quality

	BIOLOGIC POSITION	STEM QUALITY	CROWN QUALITY
	%	%	%
I	62,0	53,5	55,5
II	22,0	31,4	29,7
III	16,0	15,1	14,8

Somewhat more than half of the trees (53,5%) have good quality stems. Such trees occur in all diameter classes and their mean diameter is 23,2 cm. Their percentage in basal area, volume and volume increment is about 65%, while the percentage of the trees of medium quality stem (31,4%) is about 29%. Mean diameter of these trees is 20,2 cm. They are absent only among the largest trees in the stand (in diameter class of 35 cm). The percentage of the trees of poor quality stem is 15,1%; they are mainly the thinnest trees (mean diameter 13,0 cm). Their percentage in total basal area, volume and volume increment is about 6%.

The percentages of trees with crowns of good, medium and poor quality are similar to the percentages of the stems of these categories: 55,5%, 29,7% and 14,8% of the total number. The percentage of trees with the best quality crown in the total basal area, volume and volume increment is about 70%, and with the poorest quality crown – about 5%. Mean diameter of the trees with the first-quality crowns is 23,9 cm, diameter of the trees with medium-quality crowns is 18,9 cm, a with poor-quality crowns – 11,4 cm.

3.5. Proposal of silvicultural operations

The proposal of silvicultural measures is based on the analysis of environmental conditions, stand state and quality.

Taking into account the present state of this untended stand and its silvicultural demands, we propose mixed selection thinning of moderate weight, which includes the removal of the competitors to the selected future trees, regardless of their quality and biological position, in addition to the poorest phenotypes in the stand. The number of marked future trees per hectare is 243 to 299, average 275 among the best quality trees. Future trees are uniformly distributed throughout the area, and their percentage is 20,8% of the total number. They belong to the class of the dominant trees and their stems and crowns are of the high quality. They also belong to the group of 20% largest trees in the stand. Their mean diameter is from 24,9 to 28,1 cm, average 27,3 cm (1,3 times larger than the mean stand diameter). Their percentage in the total basal area is on average 35,0%, in volume 34,4%, and in volume increment 32,4%. The proposed thinning weight per number trees is 20,8%, i.e. 279 trees, and per volume 16,7%, i.e. 52,92 $m^3 \cdot ha^{-1}$. Mean diameter of marked trees is 18,7 cm. Such a "cautious" thinning is proposed because of a high form quotient (about 90). The trees are liable to wind throw and snow break, so the stand instability would be increased by a more intensive thinning of the upper layer or by a greater canopy opening.

4. CONCLUSIONS

An in-depth research of site and stand characteristics was carried out in an artificial spruce stand established at the site of montane beech forest in the area of Čemernik, in MU " Kačer – Zeleničje".

The stand age is 36 years. The average number of trees is 1.324 per hectare, average basal area 45,99 $m^2 \cdot ha^{-1}$, volume 317,41 $m^3 \cdot ha^{-1}$, and volume increment 14,06 $m^3 \cdot ha^{-1}$.

The thinning of the stand should have begun at the age of about 15, so as to create the conditions for the longest possible maintenance of high increment value. Current diameter increment culminated between the ages of 10 and 15 years, with the value of 11,37 mm, and current height increment maximum was reached at the ages between 15 and 20 years, with the value of 0,74 m.

Taking into account the present state of the stand and its silvicultural demands, we propose mixed selection thinning of moderate weight. 275 best-quality future trees (20,8% of the total number) are uniformly distributed throughout the area. The proposed thinning weight is about 20% of the tree number, and 15 do 20% of the volume. Such a "cautious" thinning is proposed because of a high form quotient (about 90). Any greater canopy opening would increase the instability of the stand which is liable to snow-break damage. The thinning should remove the competitors to the selected future trees, regardless of their quality and biological position, in addition to the poorest phenotypes in the stand.

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SECTION 4

INTEGRATED FOREST PROTECTION IN FORESTRY OF THE REPUBLIC OF SERBIA

Mara TABAKOVIĆ-TOŠIĆ[1]

Abstract: *Forestry science and profession of the Republic of Serbia have continuously endeavoured to carry out integrated and organised forest protection against all detrimental factors, as well as to upgrade the methods of control. As integrated forest protection means the continuous implementation of protection measures in order to ensure the undisturbed tree growth and increment and the production of the best-quality wood volume, and as this in turn includes the comprehensive and maximal protection against the harmful effects of all abiotic and biotic factors, this paper analyses its concrete implementation in the nurseries, forest plantations and in artificial and natural stands.*

Key words: integrated protection, abiotic and biotic agents, nurseries, forest plantations and stands.

1. INTRODUCTION

Forests, by their structure, as well as by the links and relationships among the individual members, belong to the most complex ecosystems. The stability of forest ecosystems is conditioned by many abiotic and biotic ecological factors, which are interrelated, complemented and exchanged. The changes of environmental factors in field conditions are spontaneous, but they can be modified by direct or indirect human impacts so much that the final result is unpredictable.

Depending on the extent of anthropogenic factors and their impacts on the formation, stability and health of the communities, there are several types of forest ecosystems. Virgin forests, which have not been under any direct human impact, are characterised by maximally natural self-regulation processes. In them, everything goes on in an uninterrupted natural process, where each individual has its place and importance. By the prevailing dynamic principle, the life goes on through permanent movement, ascents and failures, self-regulation of the entirety and its further development.

In natural (managed) forests and forest plantations, which differ in structure from virgin forests, anthropogenic factors are fully expressed. Man by his activities of changing the stand form and structure, selection of species in the establishment of plantations, methods of tending and management, affects directly the change of the composition and density of animal coenosis within the ecosystems. In natural forests and artificially established forest stands, the wildlife that are frequent inhabitants of virgin forests in the same area are regularly absent. Virgin forests offer rich and diverse food to all the animals, which in the depleted natural (managed) forests and plantations does not exist, or has an unvaried quality. The abundance of uniform food can, under some ecological conditions, lead to the outbreaks of some of the members of the zoocoenosis, to which such food is preferable.

When the fungi and insects overpopulate, and by harmful epiphytotics and outbreaks destroy the stands, they are not able to re-establish the normal state by self-regulation mechanisms, so human intervention is necessary.

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The forestry science and profession of the Republic of Serbia have continuously endeavoured to carry out integrated and organised forest protection against all detrimental factors, as well as to upgrade the methods of control. Integrated forest protection means the incessant implementation of protection measures in order to ensure the undisturbed tree growth and increment and the production of the best-quality wood volume. This includes the all-inclusive and maximal protection against the detrimental effects of all abiotic and biotic factors. Also, very important factors are the quality of forest soil and the method of management (tending, rotations, etc.). Man became aware of the necessity of integrated forest protection when he realised that the damage and mass occurrence of economically harmful organisms were not mainly the result of the destructive impact of only one factor, but of many factors which are often synchronic. The prevention of harmful activities only by preventive measures or suppression of only one harmful factor is usually insufficient to protect an endangered forest biocoenosis. Protection measures should be comprehensive and simultaneously directed against all harmful factors in a forest coenosis (Vajda, 1983).

Forest ecosystem stability depends largely on the effect, i.e. presence, of various harmful abiotic and biotic factors of global and local nature. At the local level, they are plant diseases, economically detrimental living organisms, climate factors (unfavourable air temperature, precipitation, wind), local environmental pollution (air pollution, presence of harmful pollutants and heavy metals above the critical concentrations in the soil and in vegetative parts of the plants, damage from pesticides, etc.), and at the global level, they are climate changes.

Forest management, if the measures recommended by protection are not obeyed (clear cutting, premature liberation cutting, inappropriate opening of the stand, inappropriate regeneration, etc.), can lead to disturbance which is difficult to improve subsequently.

Harmful impact of most of the above agents of forest ecosystem destabilisation can be mitigated, if not prevented, by continuous implementation of the principles and methods of integrated protection. The methods of concrete realisation in our country are explained by several examples, referring to different detrimental factors of biotic and abiotic nature, and different periods of life, i.e. plant ages.

2. INTEGRATED PROTECTION IN FOREST NURSERIES

In the first years, plants are far more endangered than adult trees. Seedlings are endangered by insects and diseases which are insignificant on older trees. Juvenile, soft and very nutritive plant tissue is an available and attractive food to insect larvae living in the soil and feeding as a rule on the roots and underground stems of herbaceous plants. The phytopathogenic phenomena are first of all the fusarioses. Some harmful effects of abiotic factors are related exclusively to juvenile plants. They are freezing or eradication during severe frosts. However, the dying of somewhat older seedlings is increasingly frequent and this etiology is still unknown. The damage in nurseries can also be caused by insects which usually feed on herbaceous, mainly weed plants.

Nurseries are the only forest facility in which the integrated protection principles and methods are fully employed, which is regulated by the Law on Seed and Planting Material and by the Law on Plant Protection. It can be summarised as follows:

- Before the nursery registration, and often before the establishment of production, the physico-chemical characteristics of the soil are examined, and the results will decide the selection of species and the implementation of the adequate agrotechnical measures.
- Many organisms which live in the soil can endanger the plantation establishment, therefore the soil most be regularly disinfected and disinsected.
- Seed germination requires abundant moisture, and it in turn favours the development of fusarioses, so the seedlings must regularly be protected by different types of fungicides.

- As it is the production in the open, to prevent the harmful impact of the climate factors (extreme air temperatures, insolation, precipitation), seedlings are protected in various ways – from covering the beds with peat and sawdust before germination, to the construction of all-weather tops.

- In the beds, the conditions are ideal for weed flourishing, so it must be removed regularly by weeding or by spraying with herbicides.

- In case of the occurrence of other biotic harmful factors, various mechanical and chemical methods of suppression can be used. It should be emphasised that phyto-pharmaceutical companies and their representatives are mainly not interested in the registration of pesticides for the implementation in forestry, because the taxes are high and the consumption is low, so the producers of forest planting material are mainly forced to apply legally only a very small number of preparations which have the permission for trade. Their permanent use without change results in the resistance, i.e. inefficacy in the suppression of the harmful biotic agent.

- In Serbia in forest nurseries, the seedlings must regularly be examined during the vegetation period and before transplanting in the field (at least two times a year) by the specialised professionals, as it is mandatory by the Law on Plant Protection. The health certificate of the planting material is issued only for healthy seedlings and only such seedlings can be used for afforestation, i.e. for the establishment of the new artificial forest stands.

3. INTEGRATED PROTECTION IN FOREST PLANTATIONS

The implementation of the principles and methods of integrated protection in forest plantations is considerably more complex and diverse, so already during their establishment, some elementary requirements of forest protection must be satisfied. This refers especially to the selection of the place and to the composition of future artificial stands, in which it should be permanently born in mind that nature does not tolerate uniformity and gaps.

A series of agents lead to the creation of labile forests, susceptible to disturbances The most important are: establishment of conifer monocultures on the sites of mixed, broadleaf-coniferous forests, establishment of pure, even-aged coniferous plantations on explicitly broadleaf sites, establishment of monocultures on the sites not suitable to the tree species, establishment of forests on the sites with deep underground water, on explicitly agricultural lands, and also in the boundary areas between forest and agricultural lands, plantation establishment of the trees introduced from other continents without previous studies of the conditions in their original sites.

The management which is not adequate for the forest type, or inappropriate operations in the forests of different ages, extensive clear cutting, agricultural intercrops, destruction of underwood and honey plants, i.e. the creation of unfavourable conditions for the maintenance of the rich fauna of parasites and predators, can also have serious consequences per forest ecosystem stability.

Further procedures in the established plantations are also significant for their stability in future. This refers especially to the absence of or untimely tending. For example, on the extensive areas under pine plantations, thinning is either absent or is too late. A too dense canopy keeps permanently a higher relative air humidity which results in the epiphytotic occurrence of some plant diseases. Physiological weakening of such trees enables a stronger infestation by xylophagous insects, primarily weevils and bark beetles. In the juvenile plantations, vigorous development of some weeds can also affect the success of afforestation. The herbicides, which could have been implemented in some cases, were mainly neglected in forestry. The lack of timely thinning increases greatly the risk of forest fire, the consequences of which can really be catastrophic.

In natural and artificially established stands, snow is the most significant of all the forms of atmospheric precipitation. When it snows in normal quantity and form, it is multiply beneficial, as water is the basic substance of living cells and of most of the physiological processes in them. However, if the quantity of the atmospheric precipitation in the form of snow increases enormously in a short time period, and if it is also wet and with large flakes, and remains in the crowns of forest trees in thick layers, then it can become a significant adverse factor.

The type, quantity and distribution of snow cannot be influenced, but as the damage caused by snow depends on the intensity of snow pressure on the crown, and in this way also on the stem, the period of its duration, tree species and age, stand type and density, soil, exposure and slope, the predispositions for the damage can be significantly mitigated by the regular implementation of various methods of integrated protection.

In the Republic of Serbia in the last fifty years, large-scale afforestation of bare land and reclamation of broadleaf degraded and coppice stands was carried out most often by using autochthonous conifers, and according to some estimates in Serbia there are about 150,000 hectares of successfully established plantations and juvenile stands (Koprivica *et al.*, 2002).

Parallel with the great investments in the establishment of forest plantations in central Serbia (e.g. bare land in the Ibar gorge, Pešter plateau, mountain Vlasina, etc.) with the species *Pinus nigra* Arn. and *Pinus sylvestris* L., which are, thanks to their biological and ecological characteristics, the most frequently used species, the demands of the production security have increased. The maintenance of forest species vitality, from the seedlings to the trees of different age classes, is a long-term process during which they can be exposed, for longer or shorter periods, to the effects of harmful biotic or abiotic factors, which sometimes become the causal agents of multiannual pathological processes with unforeseeable ecological and economic consequences. The safe production should be ensured by the adequate and permanent application of all the available methods of integrated protection, which has been insufficiently or not at all considered in some regions. The deficiency of silvicultural measures and the complete absence of preventive protection caused the multiplication of the effects of some detrimental factors on the health condition of forest plantations (Tabaković-Tošić and Lazarev, 2003).

4. INTEGRATED PROTECTION IN FOREST STANDS

The application of integrated protection principles and measures is the most complex in forest stands, because in them all the disregards made in the past are expressed; an example can be the sessile oak forests in Northeast Serbia. Their state is unsatisfactory from the aspect of conservation and vitality, which is the result of the implementation of selection management, characterised by more or less excessive felling aiming at quality. The direct consequence of such management is the presence of a high number of phenotypically poor mature trees of lower vitality. Also, such improper management in oak forests, by which the stand canopy is broken, disturbs the micro-climate in the forest. All the above, in co-action with other factors of abiotic and biotic nature, led to the rapid and mass process of the actual forest decline and dying. From the aspect of silviculture, in such cases, the integrated protection measures primarily include the elimination of the consequences of forest dying, improvement of the state and the increase of vitality (Stojanović and Krstić, 1992).

In the cases of biotic detrimental factors, forest stands are far more difficult to protect than plantations and nurseries. Especially many problems occur when they are artificial, even-aged, badly composed, and when they grow on the unfavourable sites. The area which should be treated are much larger, and the plants are much less accessible, both because of the large crown and height. In mountain regions, this is intensified by the inaccessibility of the terrain, its dissection, i.e. unfeasibility of the treatments from the air.

Forests also require permanent inspection - monitoring, to be able to intervene in good time and on small areas, by the available methods and means. The permanent control of the tendencies of population levels, i.e. the detection of the incipient phases of insect pest outbreaks or plant disease epiphytotics, eliminates the need of interventions on extensive areas, and saves manpower and means. The accurate mapping of infested areas per intensities of attack would limit the areas to be treated with insecticides, i.e. it would result in a great saving of manpower and financials and, at the same time, it would save forest living community from drastic methods of poisoning over the extensive areas.

The detrimental factors which endanger our broadleaf and coniferous forests are well known, so they will not be analysed individually. We shall single out two examples – the gypsy moth and European mistletoe and the ways of their suppression, i.e. the rehabilitation by using all the available knowledge in the field of integrated forest protection.

The gypsy moth (*Lymantria dispar* L.), one of the most hazardous pests of broadleaf forests and orchards, has had 17 outbreaks in the past 150 years in the Republic of Serbia. Damage by gypsy moth are twofold: direct - defoliation or loss of leaf mass and indirect, expressed as the consequences. Defoliation caused by caterpillar feeding leads to loss in increment, absence of fructification, physiological weakening and tree dying, as well as to creation of favourable conditions for the attack of phyto-pathogenic microorganisms, fungi and xylophagous insects, impairing the aesthetics of the area, etc.

The results of multiannual research of the gypsy moth outbreak and its suppression by insecticides of different origin and composition show that, in cases of outbreaking species such as the gypsy moth, which has the characteristics of rapid distribution over large areas, the problem should be solved on time, i.e. the suppression should be performed when the density is not high and when the infested area is small. Permanent monitoring of the gypsy moth population dynamics based on a series of characteristics which are clear indications, identify the moment when its density changes from the normal stage into the outbreak. If this is detected in good time, mechanical measures of control, i.e. the removal of egg masses which are still on the trees at the heights from which they can be removed, reduce the density of this species to the normal level, i.e. that which does not disturb the biocoenotic balance of the forest ecosystem. Egg masses which, due to inaccessibility, remain on the trees, are sufficient for the undisturbed development of other organisms whose survival wholly or partially, depends on the gypsy moth. Also, under the insignificantly increased density, but that which will, if not reduced to a normal level, cause a significant damage of leaf mass and even defoliation in the larval stage, suppression can be carried out before the damage and before permanent consequences, by applying the repellents of biological origin, such as the preparations of ash and other plant extracts which naturally repel this insect species, or in the adult stage, by using the attractants, i.e. the preparations which contain the female sexual smell and, if applied from the air, confuse the males and disable the copulation, or eliminate them from the active part of the population by luring them to specially prepared traps. Also, in the larval stage, suppression can be done by a virus preparation whose active ingredient is baculovirus *Lymantria dispar nucleopolyhedrosis virus* (LdNPV), which affects only this species, or by the preparations based on the fungus *Entomophaga maimaiga*.

The selection of the insecticide to be used in the suppression of the gypsy moth larvae depends primarily on the intensity of attack. Biological (Btk) insecticides which are applied in the gypsy moth suppression in the progradation stage, when the density is still relatively low, show the best efficacy on the younger instars (L_1 and L_2) (Tabaković-Tošić, 2005a). For older instars, a higher lethal rate is necessary, so very often the introduced quantity of the preparation causes the sublethal effects. The damage which is caused is greater than that caused by the larvae in the untreated area, because one of the consequences of the introduction of sublethal rates is the prolonged larval development. During the unfavourable weather conditions, which lead to prolonged hatching, the age structure of the population which should be suppressed is most often from L_1 to L_4. This difficulty can be eliminated by a double application of the preparation in the interval equal to the number of days of interrupted hatching (Tabaković-Tošić, 2005a), or by biotechnical insecticides. Already for two years, the Institute of Forestry in Belgrade has been researching the possibility of synergetic action of Btk-preparation with minimal rates of biotechnical preparations, aiming at the utilisation of such mixture in cases when the use of the former does not produce the satisfactory results. The minimal quantities of chemical insecticides, taking into account their basic characteristics which classify them as biotechnical preparations regarding the toxicity to other organisms, do not lead to harmful changes in the environment, so their mixture with biological insecticides can be safely used. Previous research has given the positive results, and after in-depth research in field conditions, it is expected that this possibility will be utilised in forest practice (Tabaković-Tošić, 2005b).

Under the higher intensities of attack, but still up to a definite limit, chemical pesticides of the third generation can be used, the so-called biotechnical pesticides, which are mainly environmentally safe and thanks to high selectivity and specific mechanisms, do not lead to essential disturbances in forest ecosystems (Tabaković-Tošić, 2006).

The complexity of integrated measures of protection will be shown even better by the example of the outbreak of the European mistletoe variety which infests firs, *Viscum album* var. *abietis* Beck. It will be dealt with in detail, because it is an economically very harmful autochthonous invasive species.

The distribution of this variety of European mistletoe is narrowly related to the distribution of its host - silver fir and it is limited to the European Continent. European mistletoe is a higher plant, flowering plant, but due to its root reduction, which is converted into a system of sinkers and rhizoids, it has become a parasite. The sinkers and rhizoids develop in the host plant bark and xylem and take in water and mineral matter. This way of life classifies them in the group of obligatory hemi-parasites.

According to many authors, the vectors of the European mistletoe dissemination are birds (the most active birds are thrushes, especially mistle thrush *Turdus viscivorum*). Also, the European mistletoes can spread by their berries, which fall to the lower branches and understory trees.

Seed germination occurs after several months of dormancy, and it requires intensive humidity, light, and air temperature above 4-5°C. Germination begins by the emergence of a stem-like radicle. When it reaches the host plant bark, it develops an appressorium which grows into the bark tissue, and on the lower side it develops primary sinkers. The sinkers penetrate the bark and reach the xylem, and this is the development in the first year. In the following spring, from the primary sinkers, rhizoids develop laterally in the bark. Each year, new sinkers and rhizoids develop and thus the conducting tissue of the attacked plant is widely infested.

The development of the apical bud embryo starts during the second or the third year after infection, and the first shoot appears on the surface. Depending on the light conditions, this hidden phase can last for 5-6 years. Under the particular conditions, adventitious shoots develop on the tops of rhizoids, thus enabling the vegetative spreading of the European mistletoe.

The development of this hemiparasite depends on the position of the tree or a part of a tree on which he European mistletoe seed falls, i.e. on the light regime. In forest stands in which it occurs, the European mistletoe normally develops on the fir tops and along the crown periphery, where there is no shade. With the decrease of light, its brooms are less developed and rarer and finally they disappear. This does not mean that such trees are not infested, but due to the lack of light, the buds cannot develop. After the removal of the dominant and severely infested trees, the trees from the understory are very soon covered with the brooms of the European mistletoe.

It is known that the exposure, stand type, various methods of thinning, affect the light regime and in this way indirectly affect the development of the European mistletoe.

Primary damage is reflected in the reduction of the assimilation area, decrease of increment (on average about 20%), dehydration of the tissue above the point of attack, physiological weakening of the host plant, partial or complete decline and technical damage of wood. Secondary damage is the infection of the host by wood rotting fungi, appearance of the secondary harmful insects, primarily bark beetles, stronger predisposition to windthrows. Secondary damage is mainly far more dangerous and significant for the biological balance of the attacked forest ecosystem. The calamities of bark beetles can cause dying on larger areas and thus lastingly disturb the biological balance. Fir dying on steep terrains causes the preconditions for erosion, and then such terrains are difficult for afforestation and stand regeneration.

Picture 1: Fir tree severely infested with European mistletoe

The consequences of European mistletoe infestations are more difficult on shallow, dry and leached soils, while on deep, fresh and rich soils, the intensive physiological weakening and dying of fir trees is rare. European mistletoe is today the most important autochthonous invasion species which threatens the stability of the forests with fir. The spreading of the European mistletoe is very aggressive and it is connected with the management system, i.e. the selection system is not favourable, and in such cases this hemiparasite occurs only on the tops of the crowns. Unfortunately, at some localities, selection system of management is abandoned or group-selection system is applied, which affects the forest architecture and enables the spreading of the European mistletoe to the thinner trees.

Intensive spreading of the European mistletoe in Serbia, and in this way the loss of increment of the host plants, started about thirty years ago. If this process is not stopped, the consequences could be even more difficult, including the gradual decrease of the fir percentage, which would be a very complex problem, taking into account the ecological significance of this species.

Previous results of the control of this hemiparasite show that it cannot be eradicated, and all the applied measures lead to its suppression and the maintenance of some balance. In the control of the European mistletoe, some basic principles should be respected, which are in short as follows: the action of suppression should be started as soon as possible, not allowing the infection to spread, the foci should be permanently under control, be careful in planning the suppression and take care not to destroy fir trees, special attention should be paid to the light regime in the forest, at the endangered localities the canopy should be carefully maintained, and at the infested localities the rotation should be reduced, as the European mistletoe predominantly develops on the older and dominant trees. The implementation of the above principles through a special system of management aims at the gradual removal of the infested trees by regular or intermittent fellings, site conditions should be taken into account in the determination of the intensity of individual fellings. In the stands and forests where the degree of infection is low, or the number of infested trees is insignificant, one thinning should solve the European mistletoe problem. Recently, the testing of biological efficacy of chemical preparations in the suppression of the European mistletoe has been intensified, as well as the study of the methods of their implementation, but as the experimental study is still in progress, their implementation in forest practice is not yet allowed.

5. CLIMATE CHANGE AND THE EFFECT OF POLLUTANTS - DETRIMENTAL FACTORS WHICH WILL IN FUTURE AFFECT THE INTEGRATED PROTECTION SELECTION AND QUALITY OF IMPLEMENTATION

There are numerous references in both domestic and foreign literature about the effect of climate change on ecosystems, which mainly refers to warming caused by anthropogenic increase of greenhouse gases (C, CH_4, N_2O, O_3, $HCFC_s$, CFC_s) which will initiate numerous adverse effects on forest ecosystems. For example, Willmott and Legates (1991) report that the increase of temperature ensures sufficient energy for the increased transpiration and evaporation, and because of the limited capacity of the atmosphere to absorb humidity, it is globally reflected on the increase of precipitation (cit. Liović and Županić, 2005). The increased precipitation is not uniformly distributed, so in some areas floods and soil erosion can be expected, and in other areas, the decrease of precipitation and the intensified forest dying (Bradley et al., 1987).

During the twentieth century, the changes of annual rainfall in Europe ranged from the light increase in the North, to the reduction in the South. Dry years were increasingly frequent, which directly and indirectly disturbed the stability of forest ecosystems. It is known that drought during bud development decreases the growth of shoots also in the following year. The more frequent occurrence of dry periods decreases height increment of all tree species, and especially of hydrophilic species, such as beech and spruce. Berki et al. (1998) report that sessile oak dying in the North Hungarian mountains has catastrophic levels, and the main reason is the considerable decrease of moisture content in the soil because of the rising air temperature and the decreasing precipitation since the early seventies of the last century.

It has already been stated that climate change has a great effect on forest health condition and survival. It is foreseen that the global temperature will increase for 1.5°C till 2025, i.e. for 3°C till the end of the century. In South Europe, it is estimated that the air temperature will increase for about 2°C in the winter period and for 2-3°C during summer, with the decrease of precipitation by 5-15% and humidity by 15-25%. One of the regions most affected by aridity is also the Balkan Peninsula. This will result in the decrease of vitality and in the gradual forest dying due to the following reasons: decrease of moisture in the soil, events of climate extremes, shortened vegetation periods, aggravated regeneration, reduced resistance to detrimental biotic factors (epiphytotics of pathogenic fungi or outbreaks of economically harmful insects), and all the above will lead to wide-scale forest dying (Medarević, 2005).

Among the numerous hypotheses on the hazards and destruction of forest ecosystems, in the last decades an increasing significance has been assigned to air pollution as the causes. The studies on the deposition of pollutants from the atmosphere and their effect on the ecosystems, include the sources and emissions of pollutants, their transport and transformation, deposition and effect on different receptors. The effects of pollutants on forest ecosystems have not been research to date, but this problem will have to be paid much attention to in the future period, as there are numerous proofs that the periods of drought and high temperatures, with the presence of pollutants, lead to lower tree vitality, which creates the optimal conditions for the development of many pathogenic organisms. Also, it should be emphasised that the Mediterranean pluviometric regime, which is because of the spring and autumn maxima unfavourable to forests, is just ideal for the development of parasitic fungi, so the potentials of the occurrence of fungal diseases in forests is high and they will increase from year in year.

6. CONCLUSION

The forestry science and profession of the Republic of Serbia have continuously endeavoured to carry out integrated and organised forest protection against all detrimental factors, as well as to upgrade the methods of control. Integrated forest protection means the incessant implementation of protection measures in order to ensure the undisturbed tree growth and increment and the production of the best quality wood volume. This includes the all-inclusive and maximal protection against the detrimental effects of all abiotic and biotic factors. Still, it should be recognised that forest protection in Serbia is not at a satisfactory level and that it does not act in proportion to the opportunities provided by the previous achievements of both our and international science.

Nurseries are the only forest facility in which the integrated protection principles and methods are fully employed, which is regulated by the Law on Seed and Planting Material and by the Law on Plant Protection. The final result is that only the healthy and vigorous seedlings can be used in the establishment of the new artificial forest stands i.e. for afforestation.

Parallel with the great investments in the establishment of forest plantations in central Serbia, the demands of the production security have increased. The maintenance of forest species vitality, from the seedlings to the trees of different age classes, is s long-term process during which they can be exposed, for longer or shorter periods, to the effects of harmful biotic or abiotic factors, which sometimes become the causal agents of multiannual pathological processes with unforeseeable ecological and economic consequences. The safe production should be ensured by the adequate and permanent application of all the available methods of integrated protection, which has been insufficiently or not at all considered in some regions. The deficiency of silvicultural measures and the complete absence of preventive protection caused the multiplication of the effects of some detrimental factors on the health condition of forest plantations.

The implementation of integrated protection principles and measures is the most complex in forest stands, because in them all the disregards made in the past are expressed; The hazards threatening the mature forest trees are numerous and different. Their sources lie in the ecosystem itself on the one hand, and on the other hand, in human activities which stimulate them consciously or unconsciously. The research of forest ecosystems, their self-regulation mechanisms, the base of their adaptation to site conditions, the factors which violate these bases and mechanisms, is of fundamental significance for forest protection, and forestry in general. Each intervention in natural forests should take into account that forest is a regulated community of living beings and that the laws of its maintenance and regeneration must be obeyed if its regulation mechanisms are not to be disturbed. It must be recognised with pleasure that this opinion has been increasingly introduced to our practice, although there are still occasional mistakes.

Forests also require permanent inspection - monitoring, to be able to intervene in good time and on small areas, by the available methods and means. The permanent control of the tendencies of population levels, i.e. the detection of the incipient phases of insect pest outbreaks or plant disease epiphytotics, eliminates the need of interventions on extensive areas, and saves manpower and means.

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MICROSPORIDIAN INFECTIONS IN *LYMANTRIA DISPAR* L. (LEPIDOPTERA, LYMANTRIIDAE) POPULATIONS IN SERBIA

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Abstract: *Microsporidia are common parasites of Lymantria dispar and are considered as important regulators of the insect population density. Populations of L. dispar throughout Europe have been monitored. So far, more than 20 different microsporidian isolates, belonging to at least 5 different species from 3 genera, were found. In 2005 and 2006, four L. dispar populations in Serbia were investigated for microsporidian infections. We found two microsporidian isolates belonging to the genera Vairimorpha and Endoreticulatus. The prevalence ranged from 1.58% for the Endoreticulatus isolate to 18,08 for the Vairimorpha isolate. Preliminary histological results indicate that the Vairimorpha isolate is very similar to Vairimorpha disparis and the Endoreticulatus isolate to Endoreticulatus schubergi.. Spores of the Vairimorpha isolate from a population in the region of Trstenik, which had been stored at - 20 C in frozen larvae for one year, were still viable. The two microsporidia were found for the first time in Serbia and are new species for the Serbian fauna.*

Key words: Microsporidia, *Lymantria dispar, Vairimorpha, Endoreticulatus.*

1. INTRODUCTION

The gypsy moth, Lymantria dispar is a serious defoliator of broadleaved trees, mainly oak in Europe. The most serious outbreak in Serbia occurred in the period 1948-2006. More than 40 species such as microsporidia, Virus (*Ld*NPV, *Ld*MNPV), hymenopteran and dipteran parasitoids are reported as important naturally occurring enemies of *L. dispar* in Europe (Bathon, 1996, Hoch et al., 2001). Parasitoids and predators of gypsy moth populations in former Yugoslavia were studied in detail (Ristić et al., 1998).

Enthomopathogenic microsporidia are intracellular parasites that can cause severe disease in their host *L. dispar* and are considered as important regulators of the insect population density. There are numerous reports of European *L. dispar* populations infected with microsporidia (Weiser, 1957, Cabral, 1977, Purrini, Skattula, 1978, Saftoiu et al., 1978, Zelinskaya, 1980, Pilarska and Vavra, 1991, Pilarska et al., 1998, Maddox et al., 1999). In Serbia there are reports about *Nosema serbica* by Weiser, 1964 and Sidor, 1983, and *Nosema* sp. by Sidor, 1979.

Several authors have discussed the potential of microsporidia to regulate gypsy moth density (Jeffords et al., 1988, 1989. Linde, 1993, Maddox et al., 1998). Surveys were conducted to identify microsporidia in European gypsy moth. As a result more than 20 different micro-

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sporidian isolates, belonging to at least 5 different species from 3 genera, were found. They differ in morphology, host tissue specificity, virulence and persistence (Linde et al., 1998, Solter et al., 1997, Weiser, 1998, Solter at al. 2000, Solter et al. 2005, Pilarska et al. 2006, Vavra et al. 2006).

The purpose of this study was to document microsporidian infections in different *L. dispar* populations from Serbia in order to find an isolate for augmentative release.

2. MATERIAL AND METHODS

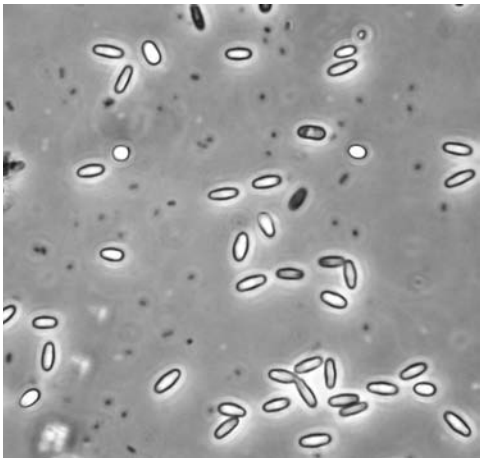
Four L. dispar populations in Serbia were investigated for microsporidian infections (F. D. Beograd, Valjevo, Trstenik, Dragovo) in 2005 and 2006. The investigations were done in oak forests with prevalence of *Quercus frainetto, Q. ceris, Q. petraea, Q. rubra* and *Q. robur*. Living larvae were collected in the field and transported to the laboratory for individual, microscopical investigation of various larval tissues. Usually, the fat body, midgut, silk glands, and Malpighian tubules were inspected. Some of the larvae collected in late May and June, 2005 were frozen and dissected one year later. Infected organs were ground in a glass homogenizer in distilled water and the homogenate was cleaned by several water washes and centrifugation. Spores isolated from frozen larvae were used for experimental infections of *L. dispar* larvae. The spore suspension was spread directly on the surface of artificial gypsy moth diet (Bell et al., 1981). Infected larvae were than placed on the artificial diet and reared in climatic chambers at 22°C.

3. RESULTS

Two microsporidian isolates belonging to the genera *Vairimorpha* and *Endoreticulatus were found in L. dispar populations from Beograd(SU Lipovica), SG Rasina (SU Trstenik), KO Dragovo (SO Rekovac). No microsporidian infections were found in SU Valjevo (Vučjak, Podgorina Vis,od. 11).*

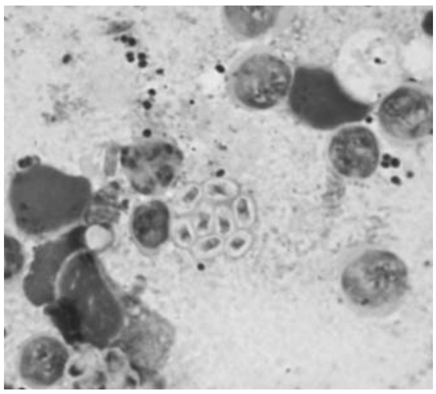
Vairimorpha sp. was found in populations from FD Rasina (SU Trstenik) in June, 2005 and *KO Dragovo (SO Rekovac) in June, 2005. It produces two spore types – octospores and diplocaryotic spores (fig. 1, fig, 2) and infects the fat body.*

Fig. 1. Fresh spores of Vairimorpha sp. 920 x



Preliminary histological results indicate that *Vairimorpha* sp. is very similar to *Vairimorpha disparis* described from a *L. dispar* in Bulgaria. For precise identification of this species detailed studies of the pathogenicity, host specificity, ultrastructural developmend and the rDNA sequence are needed. The results from laboratory infection experiments showed that spores isolated from both population in 2005, which had been stored at - 20 C in frozen larvae for one year, were still infective.

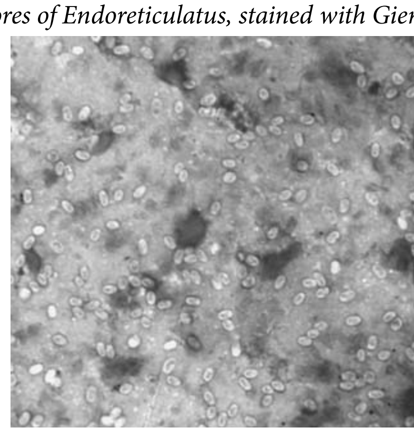
Fig. 2. Spores of Vairimorpha sp. stained with Giemsa, 1300 x



The prevalence of Vairimorpha sp. L. dispar larvae collected in F.D. Rasina (SU Trstenik) was 15, 38 % and in *KO Dragovo (SO Rekovac) 18,08 %.*

Endoreticulatus sp. was found in population from *Beograd.(F.D. Lipovica; fig. 3). It is very similar to Endoreticulatus schubergi and produces small spores enclosed in a parasitophorous vacuole.* While *Vairimorpha sp.* reproduces in the host's fat body, *Endoreticulatus* sp. is only found in midgut cells. The prevalence was 1.58%.

Fig. 3. Spores of Endoreticulatus, stained with Giemsa, 1200 x



The studies reported here represent the only recent monitoring of microsporidia infecting *L. dispar* in Serbia. The two microsporidia were found for the first time in Serbia and are new species for the Serbian fauna. Monitoring of microsporidia in *L.dispar* should be continued and new populations, especially with increasing densities should be included.

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FOREST PROTECTION AGAINST FIRE IN THE NATIONAL PARK "KOPAONIK"

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Abstract: *The incidence of forest fires, the success of fire suppression and the magnitude of damage largely depend on the detailed and elaborated prevention measures, which are aimed not only at fire prevention, but also at eliminating the conditions of fire hazard. All the constant, stable factors of significance for fire starting, spreading and intensity, climate, parent rock and soil characteristics, vegetation status, stand conditions, spatial distribution of species, stand age and stand forms are digitised and presented in the cartographic form, including the protection zones of the National Park. The connecting of GIS with expert database is in progress.*

Key words: GIS, Expert system, forest fire, in flammability, National Park.

1. INTRODUCTION

The incidence of forest fires, the success of fire suppression and the magnitude of damage largely depend on the detailed and elaborated prevention measures, which are aimed not only at fire prevention, but also at eliminating the conditions of fire hazard. The prevention measures should include all the activities that directly or indirectly decrease the number of fire events and major consequences. In fire prevention, the implementation of the Geographic Information System (GIS) facilitates the processing of spatial data. The significant quality of GIS application is the visualisation and the electronic mapping of the space, as well as an exceptionally easy data management and data updating. The most serious problem in GIS development and use is the great number of complex data, which impose strict requirements regarding the analysis and computer resources necessary for the application of such systems. The solution of this problem is GIS linking with expert systems, creating a system called Expert GIS (EGIS). Expert Systems enable the automation of problem solving for which there are no precisely defined, routine procedures. However, this demands in-depth knowledge, experience, skill and resourcefulness, owned by only a small number of experts (Waterman, 1985). Expert Systems consist of a very high number of input data which are often poorly structured, conflicting, variable, uncertain, imprecise or incomplete, as well as a large set of solutions. From the set of solutions, Expert Systems select those that are the most appropriate for the input data. In communication with the user, an important characteristic of expert systems is their capacity to explain and justify the applied method of problem solution, similar to expert methods. Based on the final outline of the Expert System, the technical staff can also make use of the expert knowledge incorporated in the system and they can undertake the appropriate actions in the absence of professionals. This is especially significant during summer months when the fire hazard is higher because of climate characteristics, and when the National Park staff is mostly absent for holidays. The aim of this

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paper is to point to the need, possibility and practical benefit of the application of the Expert System in forest protection against fire.

2. RESULTS

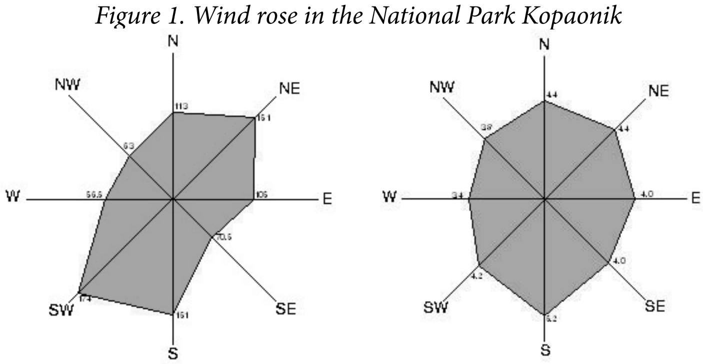
The National Park Kopaonik covers the highest parts of the mountain Kopaonik. The Park occupies the area of 11,809 ha, with the protection zone of 19,985 ha. Altitudinal difference from the foothill (400 m in the Ibar valley) to the highest peaks (Pančićev Vrh - 2017 m) is about 1600 m. The alpine flora of Mt. Kopaonik consists of 825 species and subspecies. There are 65 plant associations and 25 subassociations. The area of the National Park Kopaonik is one of the most significant centres of floristic and vegetation diversity, not only in Serbia, but also of the entire Balkan Peninsula. Altogether 91 endemic and 82 subendemic species live in the National Park. The presence of stenoendemic species (*Sempervirum kopaonikensis* Panč., *Viola kopaonikensis* Panč. and *Cardamine pancicii* Hayek) points to the significance of Kopaonik, as one of the centres of development of endemic flora of the Balkan Peninsula. The belt of beech forests ranges above the mixed forest communities in the lower belts (Turkey oak, hornbeam, oak, wild pear). The highest forest belt, above 1500 m, is covered with spruce forests. At the altitudes above 1750 m, spruce forests are thinner and they turn into a community of low shrubs. The highest zones are covered with pasture vegetation. A special characteristic of Kopaonik plants are the peatlands.

Average mean annual air temperature is 6.6°C (spring 5.3°C, summer 14.8 °C, autumn 7.9°C, winter -1.6°C). Total annual precipitation is 920.8 mm. The most rainy month is May with 108.8 mm. Mean annual air humidity accounts for 80.6%. The data analysis of the weather station Kopaonik shows that the most frequent winds are from southwest, northeast and south directions. The south, north and northeast winds are of the highest velocities (Figure 1).

The protection of the National Park consists of the following steps: estimation of fire risk, design of the scenario for fire prevention, and fire suppression in the conditions of increased risk.

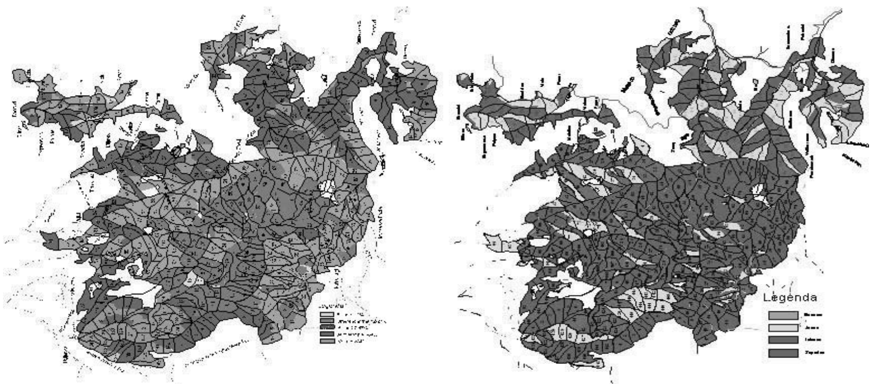
A definite formal procedure for the identification of the priority fire protection areas and also an efficient action plan do not exist, because of a great number of diverse and often contradictory factors (population of the individual areas, sites of the protected plant and animal species, land use, locations of staff and equipment in the procedures of fire prevention and suppression, distribution of responsibilities, employment of fire watchers and patrols, restrictions for park visitors, etc.). All the spatial data related to topography, hydrology, soil, vegetation, etc. can be stored, updated, analysed and processed by using GIS. The Expert System, based on spatial data and the incorporated expert knowledge, determines the list of priorities in the sense of fire hazard in the particular part of the Park and creates the protection scenarios.

Figure 1. Wind rose in the National Park Kopaonik



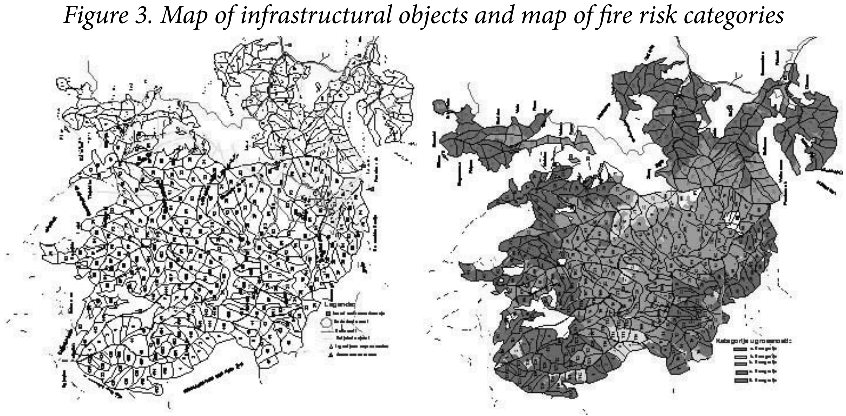
The Fire Protection Plan of the National Park Kopaonik is based on the principles of combining the GIS and Expert System. All the constant (stable) factors of significance for fire starting, spreading and intensity are digitised and presented in the cartographic form, including the protection zones of the National Park. The climate and orographic factors are analysed in detail (slope and exposure – Figure 2) significant for the fire incidence and spreading, then bedrock and soil characteristics, vegetation and litter, stand conditions, spatial distribution of species, stand age and stand forms.

Figure 2. Slope map and exposure map



The two-story stands, with the readily flammable species, are spatially defined, because of the potential development of surface fire into crown fire, and they require special measures of protection. The plan also includes the analysis of demographic movements, the development of tourist and infrastructural objects, as well as the fire hazard map (Figure 3).

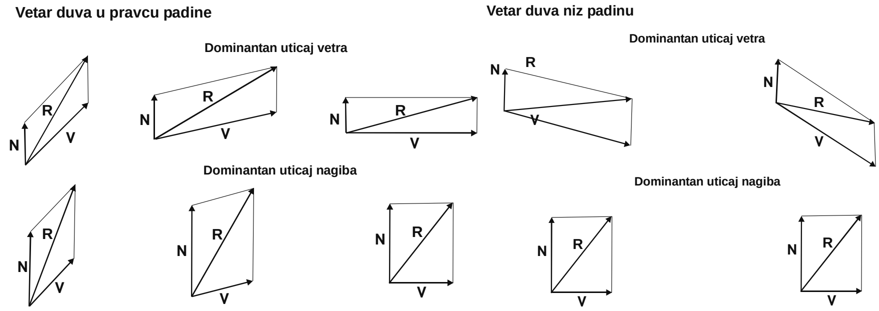
Figure 3. Map of infrastructural objects and map of fire risk categories



Based on the study data and overlaying of the cartographic material, the areas of fire hazard degrees were located, accompanied by the scenarios of potential locations of fire incidence and the directions and velocities of fire spreading depending on the weather and other conditions. The highly precise three-dimensional model of the terrain was made based on the satellite imagery and the method of the multiple oriented profiles. The resulting block diagram illustrates the true appearance of the terrain, the relief characteristics and forms.

The location of fire based on such models, with the application of the data on wind direction and velocity, enables a ready and faster organisation of fire suppression, especially taking into

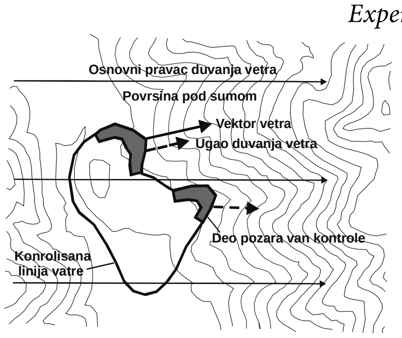
Figure 4. Direction of fire spreading depending on the slope and the dominant wind direction



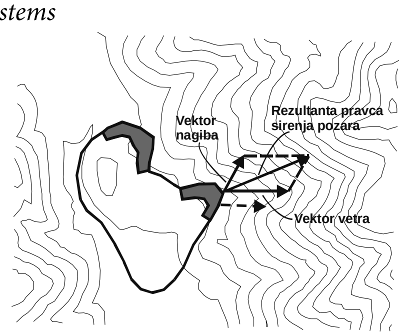
account the changes of wind direction and velocity under the effect of topographic characteristics and the effect of slope on fire spreading velocity (Figure 4).

The categorisation of fire hazard is based on the stand and site characteristics relevant for fire incidence: flammability of the wood of the edificator species in each type of real vegetation; the degree of thermophilous i.e. frigoriphilous properties and the degree of mesophilous properties; xerophilous site conditions, the indicator of which is the combination of the altitude, exposure and slope; soil type and parent rock.

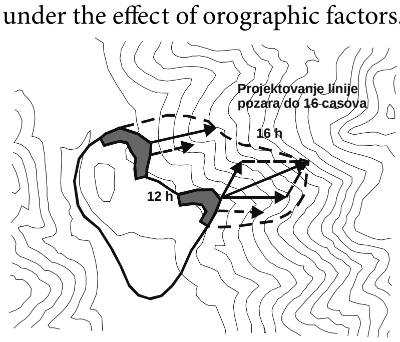
Figure 5. Hypothetical example of the organisation of fire suppression by the implementation of Expert Systems



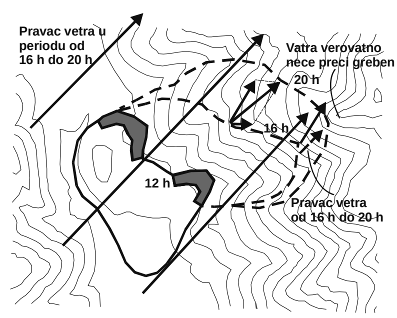
Fire starts at 9.00 h. Introduction of basic direction of the dominant wind and change of direction and velocity under the effect of orographic factors.



Calculation of the resultant of slope vector and wind vector.



Projected firefighting line till 14.00 h.



At 14.00 h wind direction changes and a new firefighting line is formed

Based on the complete analysis, altogether five categories of fire hazard were determined (Vasić, M., Ratknić, M., Topalović, M., Bucalo, V. (1998)):

1st fire hazard category are the forests and forest plantations of xerothermic and mesothermic conifers, with a higher content of resin in wood (Austrian pine and Scots pine).

2nd fire hazard category are the forests of xerothermic broadleaves (pubescent oak, flowering ash, oriental hornbeam, Turkey oak); forests of mesothermic broadleaves (hop hornbeam, sessile oak and Daleschamp's oak) on warmer exposures and bare lands on warm exposures densely covered with ground vegetation.

3rd category are the forests and plantations of mesophilous and frigoriphilous conifers with a lower content of resin (fir, spruce, Serbian spruce, Macedonian pine, larch, Douglas-fir, Weymouth pine, *Abies grandis*); forests of mesothermic broadleaves on colder exposures; bare lands on the shady sides densely covered with ground vegetation and bare lands on the sunny sides less covered with ground vegetation.

4th category are mixed forests of mesophilous and frigoriphilous conifers and broadleaves (fir, spruce, beech); bare lands on the cooler exposures with sparse ground vegetation; mixed forests of mesophilous and mesothermic broadleaves (common hornbeam and sessile oak); bare lands with dense ground vegetation in which the dominant species are: *Vaccinium myrtillis, V. vitis-ideus, V. uliginosum, Arctostaphillos uva-ursi* and similar perennial species.

5th category are the forests in which the dominant species are mesophilic broadleaf trees (beech, common hornbeam, birch, aspen); bare lands, more or less without ground vegetation; bare lands in which the dominant ground vegetation are mosses (especially *Sphagnum* sp. and *Hylocomium* sp.) or ferns *Equisetum* sp.; waterlogged areas, regardless of the cover percentage and vegetation composition.

As the result of the above research, the structures for fire protection are designed: firebreaks, firelines and watch towers, which are supported by the existing road network and hydrographic network with storages.

3. CONCLUSION

The forest fire risk, the success of fire suppression and the magnitude of damage depend of the detailed and elaborated prevention measures. Their aim is fire prevention and the elimination of the conditions of fire hazard. Based on the study data and the overlaying of the cartographic material, the areas of fire hazard degrees were located, accompanied with the scenarios of potential locations of fire incidence and the directions and velocities of fire spreading depending on the weather and other conditions. The location of fire based on such models, with the application of the data on wind direction and velocity, enables a ready and faster organisation of fire suppression, especially taking into account the changes of wind direction and velocity under the effect of topographic characteristics, and the effect of slope on the velocity of fire spreading.

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DETERMINATION OF INFESTATION BY *PLASMOPARA VITICOLA* AND CONTROLING BY FUNGICIDE BASED ON COPPER

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Abstract: *Biological examination of fungicide efficacy based on copper from copper (II) sulfat pentahidrat and calcium hidroxide) (Blue Bordo) in recomended dosage, in protection of Plasmopara viticola were done since 2004. on sort of vineyard - župljanka in localities "Irig" (Krušedol) and "Južni Banat" (Bela Crkva).*

Conditons for primary infection was in period 18.05.-23.05.2004. with fructification 29.05.2004. Science of this period grape are in phenophasis 53-60 BBCH scale. After period of primary infection there were another 11 cyclus of secundary infection. First simptomes of disesase on leaf were 01.07.2004. (phenophases 81 BBCH scale).

Experiments was done in vineyard at standard method OEPP/EPPO, Vol.14, No 2 (1984). Infestion investigation was done on leaf by method OEPP/EPPO, No1/31 (2) (skala od 0-100). Intensity of infestation was calculated by method of Towsend-Heuberger, efficacy by Abbott, and statistical analises by LSD and Duncan test.

Based on good prognosis method of patogen we can concluded that efficacy protection might be with decreased number of spraing by fungicides based on copper in normal useing dosage, what is very important because of decreasing of number of spreing and dose of useing.

Grape growing on this way and controling of useing of pesticides preparing racional condition of producing and on this way we produce halty food for our and world market.

Key words: prognosis, grape, *Plasmopara viticola*, fungicides

1. INTRODUCTION

Downy mildew is a major disease of grapes throughout the Serbia. The fungus causes direct yield losses by rotting inflorescences, clusters and shoots. Indirect losses can result from premature defoliation of vines due to foliar infections. This premature defoliation is a serious problem because it predisposes the vine to winter injury. It may take a vineyard several years to fully recover after severe winter injury.

On leaves, young infections are very small, greenish-yellow, translucent spots that are difficult to see. With time the lesions enlarge, appearing on the upper leaf surface as irregular pale-yellow to greenish-yellow spots up to 1/4 inch or more in diameter (Figure 1).

On the underside of the leaf, the fungus mycelium (the "downy mildew") can be seen within the border of the lesion as a delicate, dense, white to grayish, cotton-like growth (Figure 2). Infected tissue gradually becomes dark brown, irregular, and brittle. Severely infected leaves eventually turn brown, wither, curl, and drop. The disease attacks older leaves in late summer and autumn, producing a mosaic of small, angular, yellow to red-brown spots on the upper surface.

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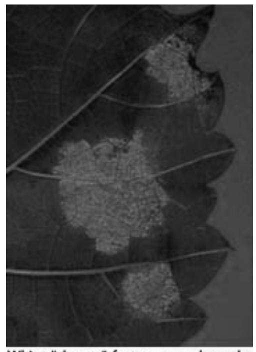
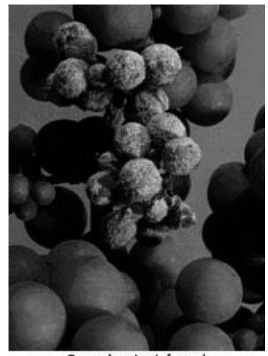
Pale yellow spots on upper surface of grape leaf caused by downy mildew.



White "downy" fungus growth on the underside of infected leaves.

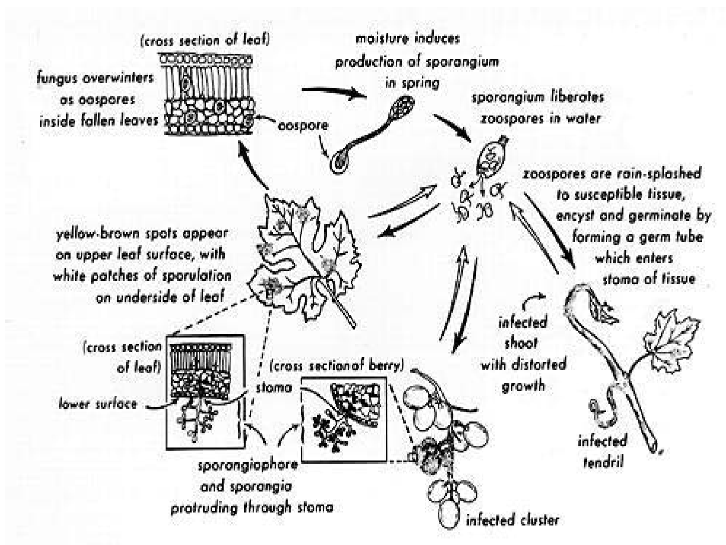


Grape berries infected with downy mildew.

Lesions commonly form along veins, and the fungus sporulates in these areas on the lower leaf surface during periods of wet weather and high humidity.

On fruit, most infection occurs during 2 distinct periods in the growing season. The first is when berries are about the size of small peas. When infected at this stage, young berries turn light brown and soft, shatter easily, and under humid conditions are often covered with the downy-like growth of the fungus (Figure 3). Generally, little infection occurs during hot summer months. As nights become cooler in late summer or early fall, the second infection period may develop. Berries infected at this time generally do not turn soft or become covered with the downy growth. Instead, they turn dull green, then dark brown to brownish-purple. They may wrinkle and shatter easily and, in severe cases, the entire fruit cluster may rot. These infected fruit will never mature normally. On shoots and tendrils, early symptoms appear as water-soaked, shiny depressions on which the dense downy mildew growth appears. Young shoots usually are stunted and become thickened and distorted. Severely infected shoots and tendrils usually die.

Downy mildew is caused by the fungus *Plasmopara viticola*. The fungus overwinters in infected leaves on the ground and possibly in diseased shoots. The overwintering spore (oospore) germinates in the spring and produces a different type of spore (sporangium). These sporangia



Disease cycle of downy mildew on grape.

are spread by wind and splashing rain. When plant parts are covered with a film of moisture, the sporangia release small swimming spores, called zoospores. Zoospores, which also are spread by splashing rain, germinate by producing a germ tube that enters the leaf through stomates (tiny pores) on the lower leaf surface. The optimum temperature for disease development is 64 to 76 degrees F (18 to 25 degrees C). The disease can tolerate a minimum temperature of 54 to 58 degrees F (12 C to 13 degrees C), and a maximum temperature of about 86 degrees F (30 degrees C). Once inside the plant, the fungus grows and spreads through tissues. Infections are usually visible as lesions in about 7-12 days. At night during periods of high humidity and temperatures above 55 degrees F (13 degrees C), the fungus grows out through the stomates of infected tissue and produces microscopic, branched, tree-like structures (sporangiophores) on the lower leaf surface. More spores (sporangia) are produced on the tips of these tree-like structures. The small sporangiophores and sporangia make up the cottony, downy mildew growth. Sporangia cause secondary infections and are spread by rain.

2. MATERIAL AND METHOD

BLUE BORDO WG (Cu from Copper (II) sulfat pentahidrat and calcium hidroxid) - Cerex agri 1, Rue des Freres Lumiere Plaisir Cerex, Francuska

Active ingradient in preparate:

Declarated: 200 +-12 g/kg cooper (Copper (II)- sulphat pentahidrat and potasium hidroxid)

Experiments were done by method PP 1/31(2) (OEPP, 1997) on sorts župljanka (Krušedol and Bela Crkva).Growing form is sphalir. Vineyard was old 16 years (Irig), and 15 years (Bela Crkva).

On bouth locality, in period of treatment, were good weather conditions for pesticide useing: wind was under 1 m/s, temperature 18-25 ^{0}C. There is no reining in period 6-8 ours after treatment.

In bouth vineyard soil was fertilised and cultivated. Drenage was not done. Weeds were distroed mechanicaly by soil cultivating.Experiments were done at instructions of method PP 1/152(2) (EPPO, 1997), in 4 repetiitions with 12 bushes (1,1x3,0 m).

Time of spreying:

I locality (Krušedol): I – 08.06.2004. – FF 57 BBCH scale; II – 18.06.2004. – FF 68 BBCH scale; III – 01.07.2004. – FF 73 BBCH scale; IV – 13.07.2004. – FF 75 BBCH scale;V – 03.08.2004. – FF 81 BBCH scale.

II locality (Bela Crkva): I – 07.06.2004. – FF 57 BBCH scale; II – 17.06.2004. – FF 68 BBCH scale; III – 28.06.2004. – FF 73 BBCH scale; IV – 07.07.2004. – FF 75 BBCH scale; V – 17.07.2004. – FF 79 BBCH scale; VI – 29.07.2004. - FF 81 BBCH scale; VII – 09.08.2004.– FF 83 BBCH scale.

Testid variants (quantity/concentration of use): On both locality were tested:

- BLUE BORDO - 0,5 % ;ž
- Bordovska čorba WP 20 - 1,5 %;
- Check – untreated;

The tipe of treatment and quantity of water on surface:: In bouth locality fungicides were spraied by atomiser “Solo” with 1000 l/ha wather.

Simpthomes and type of estimation: Starting and developing of downy mildew to moment of clear difference beetwen check and variants with fungicides. Intensity of disease was estimated by method PP 1/31(2) on 100 leaves (by scale in percentage).

Time of estimating of efficacy: The last estimation of intensity of disease was 27.08.2004. (Krušedol), and 26.08.2004. (Bela Crkva).

Type of statistical methods: Results was calculated by standard statistical methods (intensity of disease by Towsend-Heuberger, efficacy by Abott, analises of variance and Duncan test) and method PP 1/181(2) (EPPO, 1997). Importance of difference in disease intensity was estimated by analise of variance and razlika of disease intensity were estimated by analis of varijance and lsd-test.

Estimation o f p hitotoxity: Phi totoksity was co ntrolled b y met hod PP (1/135(2) (O EPP, 1997).

During the experiment there was no p hytotoxity but later we can expect. In our experiments there is no phytotoxity.

Other protection measures on experimental fild:

In bouth locality were used Kumulus DF (elementary sulfur) in protection of of Uncinula necator and insekticid i grozdovih smotavaca preparatom Talstar 10-EC (bifentrin).

Time and way of treatment: Treatment with insekticide was done in Irigu 16.06.2004., and 15.06.2004. in Bela Crkva, until treatment by fungicide Kumulus DF were done several time.

3. RESULTS AND DISCUSSION

In tabele 1 and 2 were showed results of intensity of downy mildew on leaves on control variants (59,83 %, and 66,7 %) and variants treted by copper fungicides (4,38-2,93 %, and 5,65-4,5 %). B outh variants with copper fungicides were more efficacy depending on control variant (92,69-95,62 %, a nd 90,56-93,26 %). There is no si gnificant statistical differences beetwen variants depending of disease intensity, either the lower concentration of Blue Bordo was less efficacy.

Table 1. Intensity of disease of P.viticola on leaves and efficacy of fungicides (%) in locality of Irig

Variants	Repetition				Ms Sd	Efficacy
	A	B	C	D		
BLUE BORDO – 0,5 %	2,8	5,0	4,0	5,7	4,38 a 1.3	92,69
Bordovska čorba WP 20–1.5%	6,2	4,8	4,9	6,7	5,65 a 0.9	90,56
Untreated	63,1	62,4	48,0	65,8	59,83b 8.0	-

$lsd_{0,05} = 6,03$; $lsd_{0,01} = 8,67$

Table 2. Intensity of disease of P. viticola on leaves and efficacy of fungicides (%) in locality of Bela Crkva

Variants	Repetition				Ms Sd	Efficacy
	A	B	C	D		
BLUE BORDO – 0,5 %	2,8	3,3	2,7	2,9	2,93 a 0.3	95,62
Bordovska čorba WP 20–1.5%	4,5	4,3	4,1	4,8	4,50 a 0.3	93,26
Untreated	59,8	71,7	77,5	58,0	66,7 b 9.4	-

$lsd_{0,05} = 7,71$; $lsd_{0,01} = 11,09$

4. OTHER EFFECTS

Estimation of phytotoxity:

In experiments there was no any negative effects of Blue Bordo on treated plants and didnt show any negative effects on other pests in growing plants.

Phytotoxity: Copper from Copper (II) sulphat pentahidrat and calcium hidroxide might be phytotoxity if it used on wet and cold weathe or after real time of use (ACTA, 1955;Mitić, 2000).

Resistance: Resistance of phytopathogen fungus on copper was not recognised. (Heaney, 1994; Kidd, 1988).

Mixing Blue bordo with other pesticides: Preparate BLUE BORDO are in good corelation with sulphur preparates in WP formulation, liquid fertilazers and many acaricides and insecticides.

5. CONTROL

Any practice that speeds the drying time of leaves and fruit will reduce the potential for infection. Select a planting site where vines are exposed to all-day sun, with good air circulation and soil drainage. Space vines properly in the row, and, if possible, orient the rows to maximize air movement down the row.

Sanitation is important. Remove dead leaves and berries from vines and the ground after leaf drop. It may be beneficial to cultivate the vineyard before bud break to cover old berries and other debris with soil. Cultivation also prevents overwintering spores from reaching developing vines in the spring.

To improve air circulation, control weeds and tall grasses in the vineyard and surrounding areas. When pruning, select only strong, healthy, well-colored canes of the previous year's growth. Practices such as shoot positioning and leaf removal that help to open the canopy for improved air circulation and spray coverage are also very important. Grape varieties vary greatly in their susceptibility to downy mildew. In general, *vinifera* (*Vitis vinifera*) varieties are much more susceptible than American types, and the French hybrids are somewhat intermediate in susceptibility. Cabernet Franc, Cabernet Souvignon, Catawba, Chancellor, Chardonnay, Delaware, Fredonia, Gewurytraminer, Ives, Merlot, Niagra, Pinot Blanc, Pinot Noir, Riesling, Rougeon and Sauvignon Blanc are reported to be highly susecptible to downy mildew. A good fungicide spray program is extremely important. Downy mildew can be effectively controlled by properly timed and effective fungicides based on copper (II) sulfat pentahidrat and calcium hidroxide) (Blue Bordo).

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PROGNOSIS METHOD IN *PLASMOPARA VITICOLA* AND EFFICACY OF SOME FUNGICIDES

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Abstract: *Efficacy of fungicides by biological examination based on Metsalaxil M + Folpet (Ridomil gold combi 45 WG) in recomended dose, in protection of Plasmopara viticola were done since 2005. on sort of vineyard - župljanka in localities "Irig" (Krušedol) and "Južni Banat" (Bela Crkva).*

Experiments was done in vineyard at standard method OEPP/EPPO, Vol.14, No 2 (1984). Infestion investigation was done on leaf by method OEPP/EPPO, No1/31 (2) (skala od 0-100). Intensity of infestation was calculated by method of Towsend-Heuberger, efficacy by Abbott, and statistical analises by LSD and Duncan test.

In Krušedol tested fungicides showed high efficacy on leaves of vine (from 89.8 – 87.2 %) at infestion of 75.3 % on leaf and 97.6-96.5 with infection of 92.7 on grape. Simmilar efficacy was in Bela Crkva (from 98.5 to 97.5 %) at infestation of 65.5% on leaf.

Based on good prognosis method of patogen we can concluded that efficacy protection might be with decreased number of spraing by fungicides in normal useing doses, what is very important because of decreasing of number of spreing and dose of useing.

Grape growing on this way and controling of useing of pesticides preparing racional condition of producing and on this way we produce halty food for our and world market.

Key words: prognosis, grape, *Plasmopara viticola*, fungicides

1. INTRODUCTION

The phenylamides are a highly active class of fungicides specificaly controlling plant pathogens of the oomycetes (the downy mildews) (Gisi,2002.). The penetrate the plant tissue rapidly, are translocated asropetally within the plant and inhibit r RNA syntesis in target fungi. The mode of resistance may involve one (or two) major genes and potentally several minor genes, the site of mutations in genome has not yet been mapped. Phenylamide fungicides have been in commercial use since 1978. The following active ingradients are classified as phenylamides: metalaxyl, metalaxyl M, fluralaxyl and oxsadixyl (all four Syngenta), benalaxyl (Isagro) and ofurace (Aventis) (Gisi and Ziegler, 2002).

The use strategies for PAs have been well established and they do not create controversial issues amongist member companies, officials and advisors. There have been no reported infringements of use strategies for several years. Current sensitivity monitoring data are produced by only a few research groups and the presence of resistant subpopulations have not disappeared, even though PA- containg products have been used in similar amounts and intensities over the past 20 years. This strongly suggests that the recomended anti-resistance strategies are successful. Sampling and testing methods have been published through FRAC in 1992 (EPPO Bulletin, 22, 297-322) and are still valid.

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Ridomil Gold Combi 45 WG, content as one active ingradient metalaxil. This fungicide is sistemic, and atack on single site – inhibite sintesis of rRHA cijcno mikroorganism. Because of that there is a great chance for posibility of resistance. By Ash, 2000, resistance of Plasmopara viticola on phenilamids (metalaxil) was done in Ostria, France and South Africa. Resistance at metalaxil – M (Ridomil Gold) was constant

Until now, controlling the downy mildew of grape with fungicides is still an important measure to secure good crop production. Thus it is quite necessary to find more effective and cheaper fungicides for farmers to control downy mildew of grape.

The objective of this experiment was to evaluate the effectivness of phenylamides in controlling the grape downy mildew caused by P. viticola under heavy epiphytotic condition in the field.

2. MATERIAL AND METHOD

Experiments were done by method PP 1/31(2) (OEPP, 1997) on sorts župljanka (Krušedol and Bela Crkva).Growing form is špa lir. Vineyard was old 16 years (Irig), and 15 years (Bela Crkva) with preparate and active ingradient: Ridomil Gold Combi 45 WG (Metalaxil and Folpet); Syngenta Agro Ag, Shemiestrasse P.O. Box 233, 8157, Diseldorf, Switzerland, and Ridomil Gold MZ 68 WG (a.i. Metalaxil + Mancozeb).

On bouth locality, in period of treatment, were good weather conditions for pesticide useing: wind was under 1 m/s, temperature 18-25 +C. There is no reining in period 6-8 ours after treatment.

In bouth vineyard soil was fertilised and cultivated. Drenage was not done. Weeds were distroed mechanicaly by soil cultivating.Experiments were done at instructions of method PP 1/152(2) (EPPO, 1997) at the plan of complitly stochastick event, in 4 repetiitions with 12 bushes (1,1x3,0 m).

Time of spreying:

I locality (Krušedol): I – 08.06.2005. – FF 65 BB CH scale; II – 21.06.2005. – FF 71 BB CH scale; III – 05.07.2005. – FF 73 BBCH scale; IV – 14.07.2005. – FF 75 BBCH scale;V – 21.07.2005. – FF 77 BBCH scale; 28.07.2005. – FF 79 BBCH scale.

II locality (Bela Crkva): I – 20.05.2005. – FF 15 BBCH scale; II – 31.05.2005. – FF 19 BBCH scale; III – 14.06.2005. – FF 57 BBCH scale; IV – 24.06.2005. – FF 68 BBCH scale; V – 05.07.2005. – FF 73 BBCH scale; VI – 13.07.2005. - FF 75 BBCH scale.

Testid variants (quantity/concentration of use): On both locality were tested: - Ridomil Gold Combi 45 WG – 2.0 and 2.5 kg/ha;

- Ridomil Gold MZ 68 WG – 2.5 kg/ha (standard);
- Check – untreated;

The type of treatment and quantity of water on surface: In bouth locality fungicides were spraied by atomiser “Solo” with 1000 l/ha wather.

Simptoms and type of estimation: Emergence and developing of downy mildew do emergence of clear difference beetwen check and variants with fungicides. Intensity of disease waas estimated by method PP 1/31(2) on 100 leaves (by scale in percentage).

Time of estimating of efficacy: The last estimation of intensity of disease was 27.08.2004. (Krušedol), and 26.08.2004. (Bela Crkva).

Tipe of statistical methods: Resuits was calculated by standard statistical methods (intensity of disease by Towsend-Heuberger, efficacy by Abott, analises of variance and Duncan test) and method PP 1/181(2) (EPPO, 1997). Importance of difference in desease intensity was estimated by analise of variance and intensity of deseases diference was estimated by analises of varince and lsd-test.

Estimation o f p hitotoxity: Phi totoksity was co ntrolled b y met hod PP (1/135(2) (O EPP, 1997).During the exp eriment there was no p hytotoxity but later we can exp ect. In our experiments there is no phytotoxity.

Other protection measures on experimental fild: In bouth locality were used Kumulus DF (elementary sulfur) in p rotection of of Uncinula necator and insekticid i grozdovih smotavaca preparatom Talstar 10-EC (bifentrin).

Time and way of treatment: Treatment with insekticide was done in Irigu 16.06.2004., and 15.06.2004. in Bela Crkva, until treatment by fungicide Kumulus DF were done several time.

3. RESULTS AND DISCUSSION

The data in Table 1 and 2 indicate that tretments with Ridomil Gold Combi 45 WG at rates 2.5 kg/ha and 2.0 k g/ha and Ridomil Gold MZ 68 WP gave good control of the downy mildew on grape. Results of intensity of downy mildew on leaves on control variants (75,3 %, a nd 92,7 %) and variants treted by Ridomil G old Combi 45 W G fungicides (7,7-17,2 %, a nd 2,2-3,1 %), and Ridomil Gold MZ 68 WP (9.6 – 3.2%) are shown in this tables. Variant with higher dose was more efficacy dep ending on control variant (75,3-92.7 %). There is si gnificant st atistical differences beetwen variants depending of disease intensity, either the lower concentration of Ridomil Gold Combi 45 WG was less efficacy.

Table 1. Intensity of disease of P. viticola on leaves and efficacy of fungicides (%) in locality of Krušedol - estimation : 26.07.2005

Variants	Repetition				Ms Sd	Efficacy
	A	B	C	D		
Ridomil Gold Combi 45 WG- 2.5 kg/ha	7.0	5,8	11.9	6.1	7.7 c 2.8	89.8
Ridomil Gold Combi 45 WG- 2.0 kg/ha	15.3	13.8	18.1	21.7	17.2 b 3.5	77.1
Ridomil Gold MZ 68 WP- 2.5 kg/ha	7.5	7.8	10.0	13.0	9.6 c 2.5	87.2
Untreated	80.0	65.6	70.1	85.4	75.3 a 9.0	-

$lsd_{0,05} = 7.3$;

Table 2. Intensity of disease of P. viticola on grape and efficacy of fungicides (%) in locality of Krušedol – estimation : 26.7.2005

Variants	Repetition				Ms Sd	Efficacy
	A	B	C	D		
Ridomil Gold Combi 45 WG- 2.5 kg/ha	2.8	3.0	1.0	2.0	2.2 b 0.9	97.6
Ridomil Gold Combi 45 WG- 2.0 kg/ha	3.3	2.9	3.6	2.8	3.1 b 0.4	96.6
Ridomil Gold MZ 68 WP- 2.5 kg/ha	3.8	4.1	2.0	2.8	3.2 b 0.9	96.5
Untreated	88.0	95.0	97.1	90.7	92.7a 4.1	-

$lsd_{0,05} = 3.6$;

Table 3. Intensity of disease of P.viticola on leaves and efficacy of fungicides (%) in locality of Bela Crkva – estimation : 19.07.2005.

Variants	Repetition				Ms	Sd	Efficacy
	A	B	C	D			
Ridomil Gold Combi 45 WG- 2.5 kg/ha	0.9	1.3	1.3	0.7	1.0 b	0.3	98.5
Ridomil Gold Combi 45 WG- 2.0 kg/ha	2.6	1.7	1.1	1.5	1.7 b	0.6	97.4
Ridomil Gold MZ 68 WP- 2.5 kg/ha	1.6	1.6	1.6	1.7	1.6 b	0.1	97.5
Untreated	69.6	64.8	67.1	60.6	65.5 a	3.8	-

$lsd_{0,05} = 3.0$;

In locality Bela Crkva (table 3), at intensity of infection of leaves in check of 60.6-69.6%, intensity of leaf infection (in bouth concentration) were low, at useing of preparate Ridomil Gold Combi 45 WG in bouth concentration, as at standard, from 0.7-2.6%. Efficacy of preparate was high 97.4-98.5%.

4. SENSITIVITY OF FIELD POPULATION

Much less information on resistance is available for this pathogen compared to *P. infestans.* In countries where sensitivity analyses have been conducted, the proportion of sensitive *P. viticola* isolates has remained important and more or less stable for many years (e.g. France, Italy, Switzerland).

Since many undergoes sexual recombination evry winter, the genetic diversity of the primary inoculum is very high and resistance is inherited accordin toMendelian rules, i.e. all F1 progeny isolates are intermediate (i) in sensitivity. The proportion of sensitive, intermediate and resistant isolates in F2 progeny is 1:2:1.

Therefore, the proportion of intermediates may be high in field populations, sensitive isolates will reappear and resistant isolates may not disapear. The sensitivity of populations fluctuates from year to year and within the season (Gisi, 2002). Sensitive, intermediate and resistant isolates can be detected in fields that have or havenot been treated with PAs and are in a «dynamic equilibrium» with each other. The dynamics of resistance evolution are driven not only by selection through PA fungicides, equally important are the inheritance and genetic background of resistance, as well as fitness and migration of isolates.

5. USE RECOMMENDATIONS

The use recommendations for phenylamide-based products have remained unchanged since 1997. The key quidelines for use are as follows and they may be adapted to local needs:

1. The phenylamides should be used on a preventive and curetive or eradicative basis
2. For foliar applications, the phenylamides should be used in pre-packed mixtures with an unrelated effective partner and used in a sound managment programme. Where residual partners are used, it is recommended to use between three quarters and full recommended rates. The phenylamide dosage in the mixture depends on its intrinsic activity and is defined by the respective company
3. The phenylamides should not be used as soil treatments against airborne diseases. When solo formulations are made available for soil use, strategies must be imple-mented which prevent any possibilities for foliar applications. For seed treatment, mixtures rather than straight phenylamides should be used whenever possible.

4. The n umber o f p henylamide a pplications sho uld b e limi ted (tw o t o f our co nsecutive applications per crop and year).The application intervals should not exceed 14 days and may be shorter in cases of high disease pressure. If rates and application intervals are reduced, the total amount of the phenylamide fungicide used per season shuld not exceed that of the full rate, and the total exposure time should remain the same. The rate of the mixing partners should remain the same for both intervals.
5. Phenylamide sprays are recommenced early season or during the period of active vegetative gr owth o f t he cr op. The fa rmer sho uld swi tch t o no n-phenyilamide p roducts no t later than the normal standard interval of non-phenylamide product.

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EFFECT OF DIFFERENT SOIL TYPES ON THE RISK OF BEECH INFESTATION BY THE FUNGI IN THE GENUS *NECTRIA* IN M.U. "MAJDAN-KUČAJNA"

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Abstract: *The presence of pathogenic fungi in the Nectria genus was researched in a high beech forest in Management Unit "Majdan-Kučajna" in East Serbia. The study stand consists of three types of soil (luvisol on limestones, calcomelanosol and dystric cambisol). The study was performed in the same compartment under equal macroclimate conditions, where the conditions of beech nutrition, growth, development and vitality depend on the soil type. The highest risk for beech tree infestation was identified on luvisols, i.e. on deep soil of high water holding capacity, where beech has favourable conditions for physiological processes and the uptake of water and plant nutrients from the soil. On the dystric cambisol and calcomelanosol, beech was considerably less infested by the fungi in Nectria genus.*

Key words: Beech, *Nectria coccinea, Nectria galligena, Nectria dittissima, Cryptococcus fagisuga,* luvisol, dystric cambisol, calcomelanosol

1. INTRODUCTION

Beech is a species of wide ecological range, hence it is an edifying species in numerous plant communities. Its forests develop on very different geological media (limestones, acid siliceous rocks, serpentinite-peridotite, etc.) from submontane to subalpine belt. Beech forests in Serbia occur on 10 soil types (Knežević, M. 2003). Different site conditions in which beech develops, both climate and edaphic, affect its physiological activity, nourishment and vitality.

Beech is the host of numerous pathogenic fungi, of which the species of *Nectria* genus are economically very important. *Nectria Coccinea* (Pers. ex Fr.) Fries, the agent of bark necrosis and tree dying, is the most dangerous fungus in beech forests of East Serbia, to which Management Unit "Majdan-Kučajna" belongs.

Site conditions, primarily the climate (temperature and air humidity), in which beech develops, also affect the activity, growth and development of pathogenic fungi.

In addition to exposure and slope, the macro-climate conditions are also significantly modified by soil characteristics. The available quantity of water in the soil affects the transpiration, and the transpiration determines the air humidity in the forest and the moisture of wood as the medium on which fungi develop. In beech forests, on deep soils with high water holding capacity, the favourable moisture conditions for fungal development remain longer than in the forests on shallow soils with low water holding capacity. On the other hand, sufficient quantity of water in the soil enables the more intensive physiological activity of beech, uptake of nutrients and higher tree vitality.

Species *N. coccinea* (Pers. ex Fr.) Fries. is transmitted by the scale insect *Cryptococcus fagisuga* Lindinger, which secretes a woolly substance on beech bark under which are insect

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larvae and adults. This insect does not cause great damage to wood, except that it takes in the sap from living cells and thus, in cases of very severe attacks, may cause physiological weakening of the host. So, it can be supposed that beech nutrition, i.e. the ratio of plant nutrients taken in from the soil, the chemical composition of the sap in the vascular tissues and cambium cells, can affect the scale insect which consumes this material.

The main problem for beech stands occurs 2-3 years after insect attack, when beech is infested by the fungus *N. coccinea* (Pers. ex Fr.) Fries, which causes "beech bark disease". The harmful impact of this phytopathogen is the fact that beech wood in the zone of necrotic bark is very soon infested by wood rotting agents and bark beetles, which finally lead to complete decomposition.

2. METHOD

A sample plot was established in the submontane beech forest *Fagetum moesiace submontanum* in Management Unit "Majdan-Kučajna", forest area "Severni Kučaj". The stand was divided into a network of circles, radius 12.62 m, area 0.5 ares. The circles are at a distance of 100 m, so that one circle represents 1 hectare of the stand area.

After the soil types were determined in each circle, the soil samples were taken from the representative profiles, for the laboratory analysis. Laboratory analysis consisted of the following:

- active and substitution acidity, electrometrically,
- Hydrolytic acidity and sum of adsorbed base cations, by Kappen method,
- Content of total humus, Turin method
- Content of total nitrogen, Kjeldahl method
- Readily available forms of phosphorus and potassium, AL- method,
- Textural composition of fine soil, by sedimentation method with the application of sodium pyrophosphate as peptisation means.

The pathogenic fungi were determined on each tree within the established circles and also the economically harmful insects, by standard field and laboratory methods, and a part of the study results was reported in the paper "The most important pathogenic and epixylous fungi in high beech forests of Severni Kučaj" (Marković *et al* 2005).

3. RESULTS

The altitude of the study compartments is between 406 and 513 m. The terrain is extremely dissected. Global direction of the stand exposure is West-Northwest, although individual locations in the stand have other directions of exposure, because of the severe dissection of the terrain. The slopes of the terrain in the stand range from flat ground to 35^{o}. The diversity of site conditions is complemented by edaphic conditions. The parent rock consists of limestones (with clearly distinguished elements of karst relief), and red and quartz sandstones.

Shallow typical black soils are formed on steep slopes on limestones, and colluvial black soils at places where the slopes are getting gentle.

The typical black soils in the study stand are characterised by shallow solum, they are skeletal, clay loams by particle size composition (Table 1). They are well structured, aerated and permeable. They are characterised by a high content of humus and nitrogen. The carbon nitrogen ratio is favourable for the processes of transformation of organic matter to the final products of decomposition and for the conversion of plant nutrients from the organic into mineral forms. The reaction of soil solution is somewhat lower compared to typical black soils, and also the degree of saturation with base cations. The content of available potassium in the analysed black soil is exceptionally good, while the content of phosphorus is low. Chemical characteristics of black soil are more favourable than those of other soils in the study stand. The low depth of the solum and the significant percentage of skeleton in the profile, condition the low capacity of available water. The reserve of available water in such shallow soils is soon depleted, which means that the physiological activity of beech on these soils in long periods between two rainfalls is slowed down. Beech slows down the transpiration, which reduces air humidity, and also causes some reduction of wood moisture, and the changes in the chemical composition of cell sap which is consumed by scale insects, and which is also the substance consumed by the pathogenic fungi.

Colluvial black soils in the study stand are formed on limestone bedrock, on somewhat gentler slopes, but their profiles also contain the material of siliceous origin, which was delivered from the higher parts of the terrains on quartz or red sandstones. This also affected their chemical characteristics, which are less favourable than the chemical characteristics of typical black soils. Acidity is higher, it has a lower degree of base cation saturation, the lower content of humus, total nitrogen and available forms of phosphorus and potassium. The greater depth of the solum ensures a somewhat higher water holding capacity, so moisture conditions in these soils are more favourable than those in typical black soils.

Table 1: Physical characteristics of the soil

Soil type	Depth	Coarse sand	Fine sand	Silt	Clay	Total sand	Total clay	Textural class
	cm	%	%	%	%	%	%	after Ferre
Luvisol on limestones	0-4	1.0	36.5	42.3	20.2	37.5	62.5	Loam
	4-50	0.9	31.4	41.7	26.0	32.3	67.7	Loam
	50-100	0.7	33.8	27.3	38.2	34.5	65.5	Clay loam
Dystric cambisol	0-8	9.2	47.2	11.6	32.0	56.4	43.6	Sandy clay loam
	8-80	9.2	42.3	26.1	22.4	51.5	48.5	Loam
Dystric cambisol	0-12	3.5	38.5	36.7	21.3	42.0	58.0	Loam
	12-75	3.3	34.8	36.5	25.4	38.1	61.9	Loam
Colluv. black soil	0-18	5.8	28.9	43.2	22.1	34.7	65.3	Loam
Black soil	0-50	9.0	25.1	28.6	37.3	34.1	65.9	Clay loam

Table 2: Chemical characteristics of the soil

Soil type	Depth	pH		Characteristics of adsorptive complex					Total		Readily available	
		H2O	KCl	T	S	T-S	V	Y1	Humus	N	P2O5	K2O
	cm			equiv.m.mol/100g			%	cm3	%	%	mg/100	
Luvisol on limestones	0-4	3.40	3.10	29.58	6.01	23.57	20.33	36.26	3.30	0.22	1.36	4.44
	4-50	3.20	2.80	23.72	4.36	19.36	18.37	29.79	1.26	0.20	0.00	2.57
	50-100	4.10	2.30	27.80	12.64	15.15	45.49	23.31	0.62	0.07	0.00	4.63
Dystric cambisol	0-8	3.40	3.00	31.30	3.53	27.78	11.27	42.74	3.46	0.22	2.84	14.86
	8-80	3.10	2.60	37.22	1.87	35.35	5.02	54.39	0.61	0.12	1.90	3.42
Dystric cambisol	0-12	3.60	3.40	33.27	12.23	21.04	36.75	32.38	3.62	0.23	1.47	6.51
	12-75	3.70	3.20	25.30	10.99	14.31	43.43	22.02	1.16	0.12	0.00	3.12
Black soil	0-18	4.90	4.10	55.92	44.14	11.78	78.93	18.13	7.10	0.46	3.41	23.41
Colluvial black soil	0-50	3.60	3.20	39.52	16.79	22.73	42.48	34.97	3.56	0.26	1.70	7.69

Luvisols are formed on flat limestone terrains. They are deep soils, without skeleton. By particle size distribution, humus accumulation and eluvial horizons are classified as loams, and iluvial clay, as loam. Their reaction is acid, they have low degree of base cation saturation, they are poor in plant assimilatives, and poorly humous. The great depth of the solum and the complete absence of skeleton in the profile result in the high capacity of water intake and retention. The great reserve of available water, which is retained by luvisol, enables the physiological processes in beech to be performed by full intensity also during the long dry periods between two rainfalls. This means that even in the long dry periods, the transpiration in beech forests on luvisols has greater intensity than on black soils. This ensures the higher air humidity and wood moisture favourable for the development of pathogenic fungi.

Acid brown soils are formed in the part of the stand on red and quartz sandstones. By particle size distribution, they belong to loams to sandy clay loams. The depth of the solum in the analysed profiles ranges from 75 to 80 cm. Chemical characteristics are: acid reaction of the soil solution and high hydrolytic acidity. The degree of base saturation is low, the content of available forms of plant assimilatives ranges within low limits.

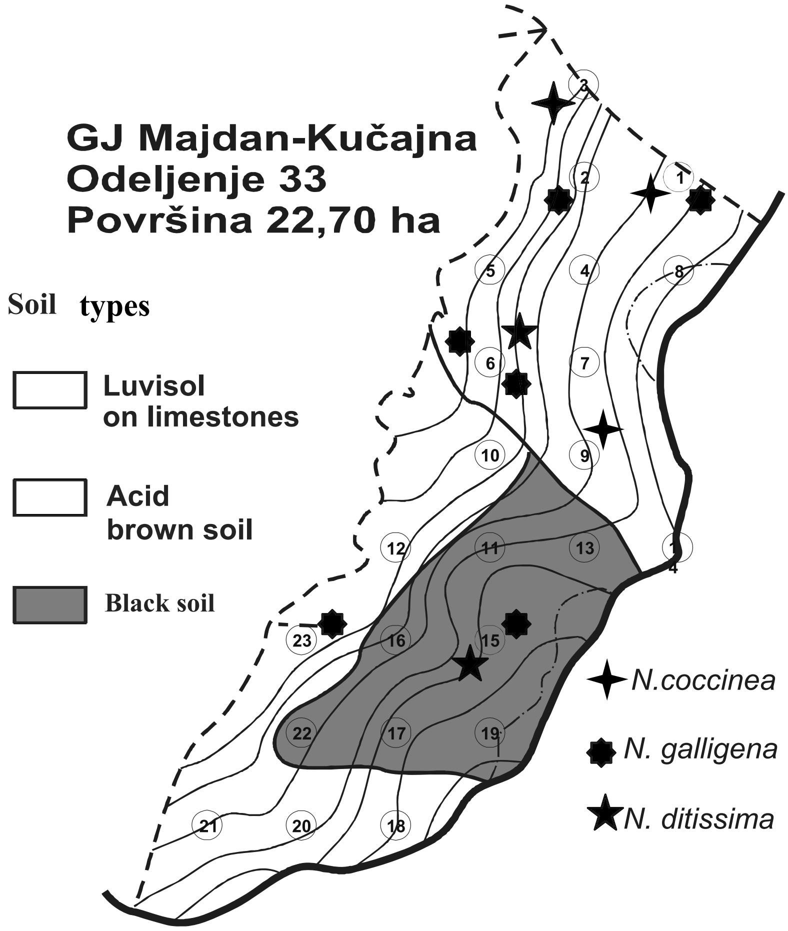
Table 3: The presence of fungi in Nectria genus in different soil types

Fungus species	Luvisol		Black soil		Dystric cambisol	
	Number of circles with fungi	Number of infested trees	Number of circles with fungi	Number of infested trees	Number of circles with fungi	Number of infested trees
N. coccinea	3	3	-	-	-	-
N. galligena	3	4	1	1	1	1
N. ditissima	1	1	1	1	-	-

Nectria coccinea (Pers.ex Fr.) Fries was identified on three circles on luvisols, while its presence was not at all detected on the trees on black soils and acid brown soils. It is considered as one of the most important harmful factors which endanger the normal development of beech trees and can lead to the epidemics. In the study stand *N. coccinea* was identified only on the trees which grow on deep soil of high water holding capacity, on the places where the physiological processes of beech (water and nutrient uptake from the soil) are not interrupted even during the long dry intervals, where wood moisture is higher than in the parts of the stand on black soil and acid brown soil. The physiological activity of beech and the transport of plant saps through the vascular tissues probably affect the nutrition of *C. fagisuga*. The presence of the fungus on the bark of beech trees which grow on luvisols, as well as its absence on beech trees which develop on the soils of lower water holding capacity, can be the result of favourable conditions for the nutrition of the main transmitter of the fungus, and also the more favourable conditions for the development of the pathogen itself.

Nectria dittissima Tul. was identified on only one beech tree on luvisol and on one tree on colluvial black soil, but it was not at all identified on beech trees on dystric cambisol. The common characteristic for luvisols and colluvial black soils (where this pathogen was present on beech trees) is that they are formed on limestone bedrock and that they are formed from the same residuum after limestone dissolution. *N. dittissima* causes open cankers and it occurs more in the younger beech coppice forests. As the study stand is a high forest of beech, it is not surprising that this fungus is present only on two trees, so it can be supposed that there is not a great risk of infection spreading. Infection is usually enabled by the injuries on the bark, and the infested trees lose the technical value and can only be used as fuelwood.

Nectria galligena Bres. infests the trees through the bark injuries, most often by frost injuries, which are in the study stand recorded on a great number of beech trees, on all three soil types. This means that there are favourable conditions for the occurrence and spreading of this pathogen in the entire stand. *N. galligena* was identified on several beech trees on three circles on luvisols, on one circle on colluvial black soil and on one on dystric cambisol. This fungus causes



open multiannual cankers mainly on the older trees in natural high forests and it leads to the reduction of their technical value. The favourable conditions for the development of this disease are wet and cold weather. Luvisols have a higher holding capacity than other soil types in the study stand, so probably for this reason a higher number of attacked trees were recorded on this soil type. According to literature, during winter months, windthrows and snow breaks usually occur on the side of the canker. This was also proved on the study circles, because the infested trees were additionally damaged by wind and snow. This reduces the technical value of the wood and represents a real danger of new infection.

4. CONCLUSION

Based on the research in Management Unit Majdan-Kučajna in compartment 33, the following three types of soil were recorded on twenty three circles: luvisol on limestones, black soil (colluvial and typical), and dystric cambisol (on red and on quartz sandstones).

The presence of pathogenic fungi from *Nectria* genus was studied on 324 trees on the circles. There are indications that beech trees on luvisols are generally more threatened by these pathogens than beech trees on acid brown soils and black soils. This is particularly evident for the fungus *N. coccinea* (Pers.ex Fr.) Fries, which was recorded only on luvisols, and whose occurrence is significantly affected by the scale insect *Criptococus fagisuga* Lindinger.

N. galligena Bres. infects the trees through the bark injuries, and in the study stand, there was a great number of trees with frost injuries on the bark. The presence of this pathogen was recorded on the trees of all soil types. Still, the greatest number of infested trees was recorded on luvisol, while on dystric cambisol and on black soil, the number of infested trees was lower.

N. dittissima Tul. which, according to references, is not frequent in high beech forests and is more frequent in coppice forests, was recorded on the lowest number of trees, i.e. only on one tree on luvisol and on one tree on dystric cambisol.

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BIOLOGICAL FUNGICIDES, GROWTH ACTIVATOR AND HORTICULTURAL OIL AS THE COMPONENTS OF THE MIXTURE FOR SIMULTANEOUS SUPPRESSION OF OAK MILDEW AND GYPSY MOTH

Vladimir LAZAREV[1], Mara TABAKOVIĆ-TOŠIĆ[2]

Abstract: *The aim of this study was to test the efficacy of some biological preparations and plant oils in the suppression of oak mildew, as potential components of the mixture with the biological insecticide D-Stop, aiming at the synchronic, combined suppression of oak mildew (Microsphaera alphitoides Griff. et Maubl.) and gypsy moth (Lymantria dispar L.).*

The tests of the biopreparations for the suppression of mildew, which have fungicide or fungistatic effects (Supresivit, Ibefungin) in forestry did not show satisfactory effects. However, the promising results were obtained with the preparation Bion 50 WG and soybean oil. Along with the satisfactory biological efficacy, these compounds were not phytotoxic to the cultivated plants, so it is supposed that, by their combination with the microbiological insecticide D-Stop, it would be possible to suppress simultaneously the gypsy moth and mildew – biotically harmful factors which can occur at the same time on oak foliage. In the future research, soybean oil will be favoured, as it has multiple uses. As it is a product for human nutrition, it is not on the Positive list of poisons, i.e. it is not ecotoxic and it is safe for application.

Key words: gypsy moth, mildew, biopreparations, soybean oil, simultaneous suppression

1. INTRODUCTION

Oak mildew – *Microsphaera alphitoides* Griff. et Maubl., for forestry the most significant biotrophic parasite from the family *Erysiphaceae*, which was introduced to Europe at the beginning of the twentieth century, is an autochthonous fungus species in North America. The high adaptation of parasites to local environmental conditions, caused its fast spreading, so today this pathogenic fungus is widespread throughout Europe. Predominantly, it infests the species from the genus *Quercus*, but also other tree species in the family *Fagaceae*.

The possibilities of plant protection against the agents of powdery mildew have been investigated for a long time, predominantly in the nurseries, and more rarely in the stands. Most often, chemical fungicides are tested and applied, mainly based on sulphur, which show good biological efficacy, but also a series of disadvantages. As their efficacy is limited in time, treatments have often to be repeated. The majority of applied preparations do not have the systemic impact, they do not protect the entire plant, but only the plant parts which are covered.

Biological protection against powdery mildew can be performed by suppression of its agents by biofungicides, such as e.g. Mycotal (based on *Verticillium lecanii*), Supresivit (based on

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Trichoderma harzianum), Ibefungin (based on *Bacillus subtilis*), or by using growth activators, the preparations which increase host resistance, such as Bion 50 WG (Soukup, 2005).

Also, some horticultural oils offer good protection against the attack of the fungi from the order *Erysiphales*. The highest biological efficacy was achieved by neem oil (oil extracted from the plant *Azadirachta indica*), soybean oil, garlic oil and jojoba oil (oil from a bean species).

The aim of this study was to examine the efficacy of some biological preparations and horticultural oils in the suppression of oak mildew, as the potential components of the mixture with the biological insecticide D-Stop, in the aim of synchronic, combined, suppression of powdery mildew and gypsy moth.

2. MATERIAL AND METHOD

The biological efficacy of the oak powdery mildew suppression by two chemical and two biological preparations, one growth activator and one horticultural oil was examined in field tests, on sessile oak container seedlings 1+0 and 2+0 which were previously exposed to the infection potential of the parasitic fungus *Microsphaera alphitoide*. The tested chemical preparations were Sulphur SC (concentrated suspension, active ingredient sulphur 825 g/l, rate - concentration 0.6%) and Kolosul (concentrated suspension, active ingredient sulphur 800 g/kg, rate - concentration 0.5%). The tested biological fungicides were: Supresivit (concentrated suspension, active ingredient of the spore *Trichoderma harzianum*, CFU 1.4 x 10^{10} spores in g^{-1}) in concentrations 0.1%, 0.2% and 0.5%, Ibefungin (concentrated suspension, active ingredient of the spore *Bacillus subtilis*, IBE 711 1 x 10^{9}) in concentrations 0.2% and 0.5%, growth activator Bion 50 WG in concentration 0.1%. The tested horticultural oil was soybean oil in 1% concentration (oil mixed with plant extract). Each treatment included 10 seedlings 1+0 and 2+0, and the rates of the above preparations were 0.3 l (1+0) and 0.5 l (2+0). The treatments in 5 repetitions were performed in the period from May 15th to Aug 5th 2005. The control consisted of 10 seedlings each of the ages 1+0 and 2+0, which were not treated.

Data processing was based on the analysis of infected and uninfected leaves 10 days after the last treatment, and the data were presented as the percentages of diseased leaves per each treatment.

3. RESULTS AND DISCUSSION

The efficacy of the tested preparations of different composition for the suppression of powdery mildew, i.e. the efficacy of the applied treatment, is presented in Table 1 and Diagram 1.

The analysis of the results in the Table confirms the literature data and the results reported by other authors, that the best efficacy in the suppression of oak mildew is achieved by applying the chemical fungicide with sulphur as the active ingredient (in this case, Sulphur SC and Kolosul). The treatments of 1-year-old and 2-year-old sessile oak container seedlings, with the rates of 0.3 and 0.5 l/ha, reached almost 100% protection, i.e., on 1-year-old seedlings there were no infested leaves, while the percentage on 2-year-old seedlings was 1.0%.

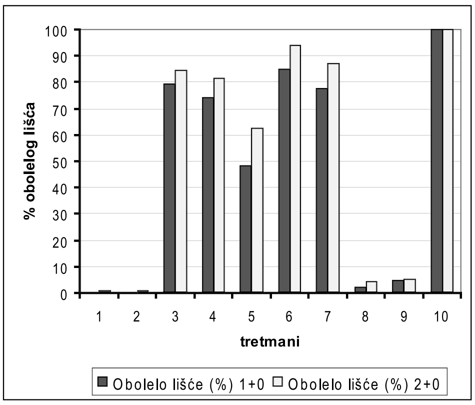
The surprisingly poor effects were achieved by the tested biological preparations. The number of infested leaves was high even under higher concentrations (0.5%): (Supresivit 48.3-62.6%, Ibefungin even 77.7-87.2%), i.e., biopreparations with fungicidal or fungistatic effects in the suppression of other disease agents on forest plants, were not efficient in the suppression of powdery mildew in this case. Similar results were obtained by the implementation of biopreparation PreFeRal (PFR) in 0.2% concentration which is based on the fungus *Paecilomyces fumorosoreus* (Soukup, 2005).

The preparation based on growth activator Bion 50 WG was very efficient, which can also be stated for soybean oil (percentage of infested leaves 2.2 – 5.2%). The efficacy of chemical fun-

Table 1. Percentage of the leaves infested by oak mildew (Microsphaera alphitoides Griff. et Maubl.) after the treatment

Treatment No.	Preparation	Concentration (%)	Infested leaves (%)	
			1+0	2+0
1	Sulphur SC	0.6	0	1.0
2	Kolosul	0.5	0	1.0
3	Supresivit	0.1	79.4	84.6
4		0.2	74.2	81.5
5		0.5	48.3	62.6
6	Ibefungin	0.2	85.1	93.9
7		0.5	77.7	87.2
8	Bion 50 WG	0.1	2.2	4.3
9	Soybean oil	1.0	4.8	5.2
10	Control (untreated)	-	100.0	100.0

Diagram 1. Efficacy of the applied treatments for the suppression of Microsphaera alphitoides



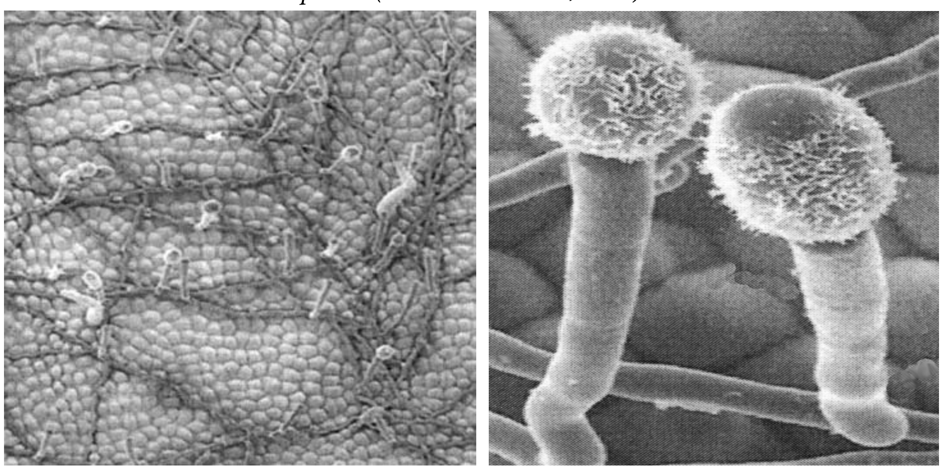
gicides, the preparation Bion 50 WG and soybean oil is especially high compared to the control. The efficacy of Bion 50 WG is especially significant; it is almost equal to that of the chemical fungicide based on sulphur.

Individual oils, which are most often the combination of highly purified petroleum oil with some emulsifier (Sunspray[R], Scalecide[R], Volck[R]), dissolved in water and applied by spraying, are an efficient protection against many insect pests. Another group with the same purpose consists of the oils of plant origin. Their advantages as pesticides are the safe implementation, efficacy and limited effect on nontarget insects, but care should be taken not to treat the vulnerable plants and not to apply during the dry period, because it can lead to phytotoxicity. Also, oils should not be combined with sulphuric compounds or with the preparations containing sulphur (e.g. Kaptan, Karatan), because their mixture forms phytotoxic substances.

Good fungicide effects were recorded with neem oil, extracted from the plant *Azadirachta indica,* which is present in the preparations Trilogy[R] and Neem Triact 90 EC (Soukup, 2005). In addition to its efficacy in powdery mildew suppression, this preparation stimulates the vitality of the treated plants, and also it has insecticidal characteristics. Different active ingredients in this oil act as repellents, nourishment inhibitors, inhibitors of growth and egg laying, as sterilants and as poisons, and applied on plants, they have contact and systemic impacts.

In the aim of preventing the reduction of assimilation organs by defoliators (primarily *Lymantria dispar*) and agents of oak mildew (*Microsphaera alphitoides*), it is necessary to ensure the synchronic protection of leaves. This could be achieved by the combined impact of the preparations which simultaneously suppress insect defoliators and ensure the preventive protection against the attack of powdery mildew, which can hibernate in the buds (Lazarev, 2005) (Figure 1).

Figure 1. Hyphae and conidiophores of powdery mildew under electronic microscope: a) colony of Oidium sp. with hyphae which branch under right angle to growth direction; b) mature conidiophores (Celio & Hausbeck, 1998)



Based on the preliminary results, it is supposed that the mixture of soybean oil, which showed good fungicidal characteristics in oak mildew suppression, and biological insecticide D-Stop, could give good results in the synchronic suppression of gypsy moth and preventive foliage protection against the initial infection by oak mildew.

4. CONCLUSIONS

The comparison of the efficacy achieved by two chemical and two biological preparations, one growth activator, and one horticultural oil, it was concluded that the best results in the suppression of oak mildew is achieved by the application of chemical fungicides with active ingredient sulphur (Sulphur SC and Kolosul), then by the growth activator (Bion 50 WG), and by soybean oil. Biological preparations (Supresivit, Ibefungin) were not efficient in any of the study concentrations.

In the future research of the compatibility, efficacy and stability of the mixture of fungicides for the suppression of oak mildew and insecticide D-Stop, for gypsy moth suppression, advantage is given to soybean oil, which has multiple implementation, and as this is a product for human nutrition, it is not on the Positive list of poisons, it is not ecotoxic i.e. it is safe for implementation.

Previous studies provide a good base for further research of the implementation of the mixture of soybean oil and bioinsecticide D-Stop in the aim of synchronic suppression of gypsy moth caterpillars and oak mildew, which would lead to multiple benefits and economy in the rehabilitation of the infested oak forests.

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BIOLOGICAL STRUGGLE AGAINST THE MAIN PESTS IN THE FORESTS OF BULGARIA

Iantcho NAIDENOV, Marii ZAMFIROV, Vera ROSNEVA, Reni BECHEVA[1]

Abstract: *The main leaf pests in the forests of Bulgaria are as follows: Lymantria dispar L., Thaumatopoea pityocampa Schiff., Neodiprion sertifer Geoffr., the pests of Geometridae and Tortricidae families. Having in mind the role of forests as basic climate regulating and site forming factor, till 1971 the forest protection practices in Bulgaria are directed mainly towards utilization of biological means for plant protection. As result of the close cooperation among forest protection specialists from the institutes and in the practice, the biological and hormonal plat protection reached up to 90% of the performed protective measures in 1992. This paper presents some experiences of the Forest Protection Station – Sofia, on application of plant protective products on the base of B. thuringiensis and Spinosad for struggle against L. dispar, Th. Pityocampa, Geometridae and Tortricidae.*

Key words: *Lymantria dispar* L., *Thaumatopoea pityocampa* Schiff., *Neodiprion sertifer* Geoffr., *Geometridae* and *Tortricidae*, biological and hormonal plant protective products.

1. INTRODUCTION

In the beginning of 1950s the mass appearance (calamity) of gipsy moth (*Limantria dispar* L.) imposed the treatment of about 1 500 000 ha with broadly applied at that time DDT. Subsequently it was established that almost all useful insects, which are natural enemies of pests disappeared. Having this in mind the scientific researchers, forest protection workers and forests managers, as well as the board of the forest administration directed the forest protection activities towards artificial breeding and reproduction of predatory insects and pests on defoliating insects in our forests.

According Tsankov et al. (1974) the first experiments with product on the base of Bacillus thuringiensis were held in 1969 and with hormonal products – in 1982-83. We should underline that the investigations and practical work of Prof. D. Stefanov, Prof. G. Ganchev, Prof. G. Tsankov, Prof. Pl. Mirchev, Prof. B. Rossnev, Dr. V. Vatov, Dr. N. Bochev, Dr. T. Chernev, as well as the support of eng. I. Gruev and eng. S. Dimitrov – leaders of the forests administration, put the foundation of strategy and define the priorities in forest protection through biological struggle. All this reflects in the contemporary normative base.

2. OBJECT AND METHODS

Object of this investigation is the comparison of results from treatments with biological and hormonal products respectively, against defoliating insects. The treatments were performed in the last years as there were attacks by gipsy moth (*Lymantria dispar* L.) and pests from Geometridae and Torticidae on oaks in the period 2004-2005, as well as development of *Neodiprion sertifer* Geoffr. and *Thaumetopoea pityocampa* Den. Et Schiff.

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1 Forest protection Station

According the requirements of the European and Mediterranean organizations on plant protection the experiments were performed by ULV treatment with recorded norms of consumption for every product and pest species. Each trial includes no less than 40 ha area in three repetitions. The expected percentage of defoliation was determined in accordance with Regulation No56/2004 and the treatments were performed as follows: for *Lymantria dispar* – at stage of larva (age class I-II) with single participation of age class III; for Geometridae and Torticidae – I-III age class, singly IV larvae age; for *Neodiprion sertifer* – at II-I age class (singly V); for *Thaumetopoea pityocampa* – at I-III age class (singly IV larvae age).

The efficiency of treatments was determined as the percentage of caterpillars and pseudo-caterpillars mortality, according to the formula:

$$E = \frac{N - N_0}{N} \times 100$$

where: N – number of the caterpillars before the treatment

N_0 – alive caterpillars at accounting the effect

Three cheese-cloth isolators were set up for each variant on 3 different trees. The real percentage of defoliation was recorded in non-treated control sample plots.

The following products were tested:

Table 1.

Active substance	Products	Norm of consumption
Lymantria dispar L.		
1. Bacillus thuringiensis	Forey 48 V	4 000 ml/ha
	Batic	2 000 ml/ha (1 500 ml + 500 ml Akarzin/ha)
	Custom Larvo BT 250	ml + 1 050 ml Akarzin + 2 700 ml water/ha
	Condor	1 250 ml/ha
	D-Stop	1,5 l/dka
2. Spinozad	Tracer 480 SK	50 ml + 500 ml Akrazin + 2 450 ml water/ha
3. Tebuphenozid	Mimic 240 LV	400 ml + 160 ml water/ha
4. Diflubenzuron	Dimilin 480 SK	100 ml + 500 ml Akrazin + 2400 ml water/ha
	Forester 48 SK	100 ml + 500 ml Akrazin + 2400 ml water/ha
Geometridae и Tortricidae		
1. Bacillus thuringiensis	Batic	1 500 ml + 500 ml Akrazin/ha
	Forey 48 V	1500 ml/ha
2. Diflubenzuron	Dimilin 480 SK	100 ml + 500 ml Akrazin + 240 ml water/ha
	Forester 48 SK	100 ml + 500 мml Akrazin + 2 400 ml water/ha
3. Tebuphenozid	Mimic 240 LV 400	ml + 1600 ml water/ha
Ръждива борова листна оса (Neodiprion sertifer Geoffr.)		
1. Diflubenzuron	Dimilin 480 SK	100 ml + 500 ml Akrazin + 240 ml water/ha
	Forester 48 SK	100 ml + 500 ml Akrazin + 2400 ml water/ha
2. Spinozad	Tracer 480 SK	30 ml + 500 ml Akrazin + 2470 ml water/ha
3. Tebuphenozid	Mimic 240 LV	400 ml + 1600 ml water/ha
Борова процесионка (Thaumetopoea pityocampa Den. et Schiff.)		
1. Bacillus thuringiensis	Batic	1 500 ml + 500 ml Akrazin/ha
	Forey 48V	1200 ml/ha
	D-Stop	1,5 l/dka
2. Diflubenzuron	Dimilin 480 SK	100 ml + 500 ml Akrazin + 2400 ml water/ha
	Forester 48 SK	100 ml + 500 мml Akrazin + 2 400 ml water/ha
3. Spinozad	Tracer 480 SK	50 ml + 500 ml Akrazin + 2450 ml water/ha
4. Tebuphenozid	Mimic 240 LV	400 ml + 1600 ml water/ha

3. RESULTS AND DISCUSSION

In the last 15 years the experience in our country showed that the biological struggle against the main pests in the forest ecosystems should be emphasized as priority direction in the forest protection activities (Figure 1). At the same time the utilization of hormonal products also proved to have their place in plant protection.

Figure 1. Types of avio-treatments against the main defoliating pests in the forest ecosystems

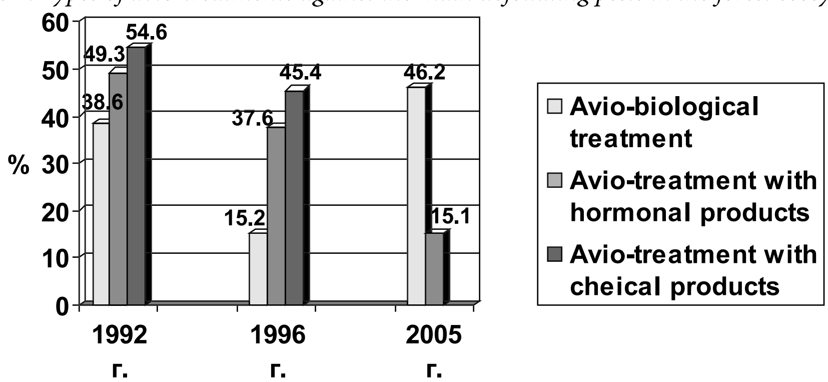

Table 2 presents the results from parallel experimental-and-productive treatments with different biological and hormonal products on one and the same pest or group of pests, in one and the same time. The data show that the treatment against insect pests from Geometridae and Torticidae at larvae ages of I-III, singly of IV classes gives very good results. The efficiency of treatments varies from 85 up to 96.1%, the highest mortality being recorded for Tracer 480 SK (96.1%) and the lowest – for Batic. The hormonal products Dimilin 480 SK and Forester 48 SK based on Diflubenzuron and Mimic 240 LV based on Tebuphenozid ensure comparatively good protection of the leaves against this group of insect pests. The total effect of the Dimilin 480 SK and Forester 48 SK is however lower as the defoliation after treatment with these products is 15 and 20% respectively. No defoliation is observed after treatment with Mimic 240 LV, due to the fact that just after the treatment the larvae stop to eat, 2-3 days later under the influence of the enzymes, which these products contain, the caterpillars start to search place to turn into pupae and die from dehydration.

The same tendency is observed at the treatment of gipsy moth (*Lymantria dispar* L.). The most efficient proved to be the product D-Stop (produced by the Biological Centre in Zranani) at consumption norm 2.0 l/ha, based on Bacillus thuringiensis – 94.5%; Tracer 480 SK, based on Spinozad – 97.2% and the hormonal product Mimic 240 LV, based on Tebuphenozid– 98.3%.

The effect of the products based on Diflubenzuron is comparatively good – 79.1 % for Forester 48 SK and 90.2% for Dimilin 480 SK, in this case the actual defoliation being 20% and 18% respectively.

Very important for the forest protection in Bulgaria is the registration of a bio-product against *Neodiprion sertifer*. The experimental treatments performed in the country in the period 2001-2004 allowed the registration of Tracer 480 SK based on Spinozad. The results from the parallel treatments against this pest showed that at doze 30 ml/ha + 500 ml/ha (Akarzin – mineral oil) and 2470 ml/ha H_2O or prepared total solution of 3 l/ha and ULV treatment with Tracer 480 SK bio-product its efficiency is 93.6%, followed by Mimic 240 LV – 87.8% (Table 2).

The products Dimilin 480 SK and Forester 48 SK based on Diflubenzuron showed efficiency of 84.9% and 81.4% respectively and defoliation from 15 up to 30%.

The data presented in Table 2 show that treatment with biological products based on Bacillus thuringiensis and Spinozad against *Thaumetopoea pityocampa* gives excellent results. The differences in the efficiency of treatments with D-Stop at dozes 1.0 l/ha, 1.5 l/ha and 2.0 l/ha are minimal, which allows to make the treatment cheaper up to 50%. Tracer 480 SK product also has high efficiency – 94.6 %, while the efficiency of the hormonal products Dimilin 480 SK and Forester 48 SK is from 85.8% up to 90.2% with defoliation from 15 up to 20%.

The most efficient of the hormonal products proved to be Mimic 240 LV based on Tebuphenozid no additional defoliation was observed due to the fact that several hours after treatment with it the larvae stop to eat and search place to turn into pupae.

Extremely important is the fact that in case of calamity development, especially for gipsy moth (*Lymantria dispar*), the period of caterpillars' incubation is up to 45 days, while the effect bio-products last for 15-20 days. This means that the treatment with bio-products should be performed twice or a priority to the hormonal products based on Diflubenzuron and Tebuphenozid should be given.

The treatments against *Thaumetopoea pityocampa* in case of late incubation of caterpillars (after 25 September) and at stable temperature values about 15-18°C are better to be performed with hormonal products.

The results of our investigations and of the mass scale productive treatments show that the most efficient are the treatments against defoliating larvae when they are at I-II age classes with single individuals at III age class.

4. CONCLUSION

Based on our present experience and the results achieved we can make the conclusion that the registered products for plant protection against the main leaves affecting insect pests in our forest ecosystems, based on Bacillus thuringiensis and Spinozad ensure high efficiency of the treatments. In the same time the most efficient are the treatments in II-III larvae age classes. There are no data, however, about the influence of these products on the humans, useful entomofauna and mammals.

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A CONTRIBUTION TO THE STUDY OF THE EFFECTS OF SOME FACTORS ON THE VITALITY OF GYPSY MOTH POPULATIONS

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Abstract: *Factors such as geographic origin, population density and host plant can have an essential effect on the population vitality in the following year. The effect of these factors on some of the parameters which characterise the population vitality was studied, e.g. average number of eggs per egg mass, average egg weight, and the percentage of parasitized and hatched eggs. The effect of individual factors on the analysed parameters was calculated by the multi-factorial analysis of variance. The egg masses used in the analysis were collected during the autumn 2003 throughout Serbia. Egg masses were classified according to their geographic origin, population density and dominant tree species in the stand in which they were collected. The study data suggest that the geographic origin and population density have a significant effect on the average number and weight of eggs in egg mass. The tree species does not have a statistically significant effect on the above two parameters. The geographic origin and the tree species have a significant effect also on the percentage of parasitism, while population density does not have a statistically significant effect on this parameter. The hatching percentage depends on the origin and on the population density, while the tree species does not have a statistically significant effect on hatching percentage.*

Key words: environmental factors, gypsy moth, population vitality

1. INTRODUCTION

The gypsy moth population dynamics, in addition to environmental factors, is largely affected also by hereditary factors. Thus, the reduction of leaf quality, which follows the outbreak, favours the less selective genotypes and the caterpillars which tolerate the lower quality food, while the frequency of selective genotypes increases in the period of latency (Stockhoff, 1991). The spatially close populations have a similar genetic constitution. This is the consequence of the crossing of individuals from these populations during the preceding outbreaks. The differences between them are the consequence of the expression of different genes resulting from the selection pressure of the environmental factors. The environmental factors, through the maternal effect, can have an effect on the insect population dynamics independent on the hereditary factors. Maternal effect is a mechanism by which the environmental conditions in the observed year are expressed by phenotype variations of the progeny in the following year (Rossiter, 1994). It describes the parental effects on the progeny which are not regulated by Mendel's laws of inheritance (Hunter, 2002). The mechanism by which the females influence their progeny's phenotype is manifested by the difference in egg quality, by the variation of their size and quality (Rossiter, 1991; Rossiter, 1992). The caterpillar survival without food, and thus also the period of spreading, depends on the content of vitelline and glycine within the eggs (Diss *et al.* 1996). The spreading of

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freshly hatched gypsy moth larvae at the velocity of 5 km/h, from the top of the 10 m high tree, is in one attempt about 120 m (Mason and McManus 1981), but there may be several attempts if the larva does not fall on the favourable host plant. The number of attempts of spreading the hatched larvae depends on their survival period. As this is the only form of the gypsy moth spreading in the progradation years, when there is no movement of grown-up caterpillars searching for new food after the complete defoliation, then the effect of environmental conditions in the previous generation on the survival of young caterpillars has an even higher significance (Mason and McManus 1981).

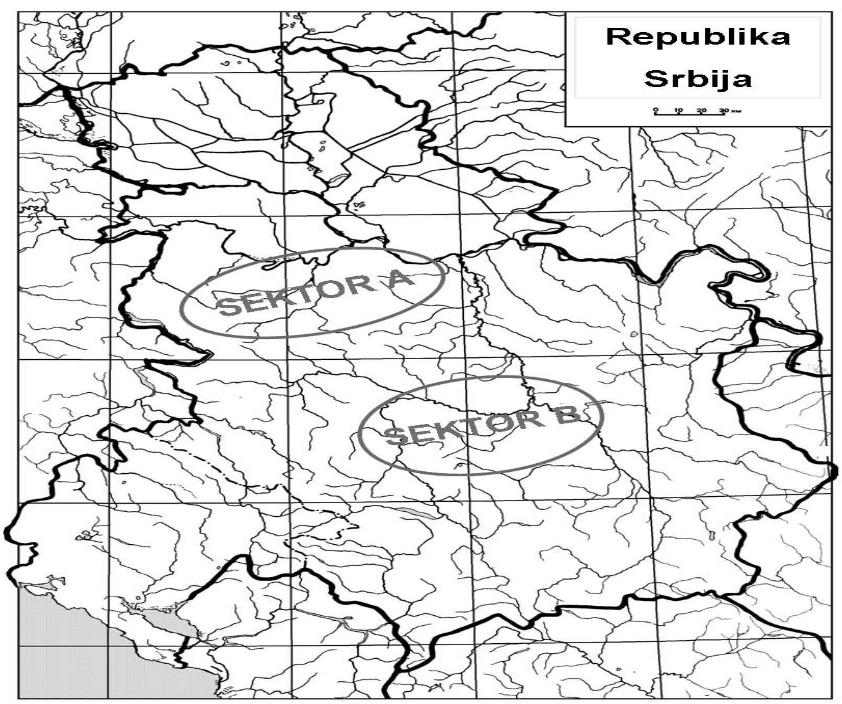
This paper presents the effect of the population origin, but also the environmental factors (host plant and density), on the vitality of the gypsy moth population.

2. MATERIAL AND METHODS

The gypsy moth egg masses, collected during autumn 2003 throughout Serbia, were analysed. The egg masses were first cleaned from the hairs and examined to determine the numbers of vital, unfertilised and parasitized eggs. Then 100 eggs were taken from each egg mass, and their mass was measured on the digital balance, to the thousandth part of gram. The same eggs were then kept in the refrigerator at the temperature of 5°C till the middle of January. The eggs were then placed for hatching which was monitored in the test tubes at room temperature which varied between 18 and 20 °C. The test tubes were examined once a week, and the number of hatched larvae was at the end of the experiment summed up to determine the total hatching percentage.

Before the statistical processing, the egg masses were first classified by the geographic origin (Figure 1), population density and dominant tree species (beech, oak) in the stands from which they were collected. Population density was expressed by the number of egg masses per hectare. Egg

Figure 1. Locations from which the gypsy moth egg masses were collected



masses from the populations with up to 100 egg masses per hectare were classified in the low density category, while those from the populations with more than 1,000 egg masses were classified in the high density category. The independent variables (origin, species density) were used as the factors in the multifactorial analysis of variance. The dependent variables were average egg weight per egg mass, average number of eggs per egg mass, hatching percentage, and parasitism percentage.

3. RESULTS

Table 1 presents the results of the multifactorial analysis of variance of the effect of factors on some variables which characterise the gypsy moth population vitality.

Table 1. Multifactorial analysis of variance of the factors which affect the variables which characterise the population vitality

Factors	Variables							
	Egg mass		Egg number in egg mass		Hatching %		Parasitism %	
	F	P	F	P	F	P	F	P
Geographic origin	**5.26**	**0.0222**	**31.21**	**0.0000**	**9.49**	**0.0022**	**142.92**	**0.0000**
Population density	**7.78**	**0.0055**	**6.92**	**0.0087**	**9.90**	**0.0017**	2.15	0.1427
Host plant	1.17	0.2797	1.75	0.1863	1.14	0.2851	**4.18**	**0.413**

Factors with bold F and P values had statistically significant effects on the study variable which characterises the population vitality, probability level 95%.

The geographic origin of the gypsy moth population has a statistically significant effect on the average egg weight, total number of eggs per egg mass, and the hatching and parasitism percentages.

Population density has a statistically significant effect on the average egg weight, total number of eggs per egg mass, and the hatching percentage, but it has not a statistically significant effect on the parasitism.

The host plant from which egg masses were collected has a statistically significant effect only on the percentage of parasitized eggs per egg mass.

Table 2 presents the average values of the study parameters shown by the variants of the study factors.

Table 2. Number of analysed egg masses and the average values of the study parameters shown by the variants of the study factors.

Factors	Variants	N	Variables			
			Egg mass (mg)	Number of eggs in egg mass	% hatching	% parasitism
			average			
Geographic origin	sector A	385	**0. 631**	**704.4**	**54.9**	**18.6**
	sector B	216	**0. 654**	**550.6**	**64.5**	**3.5**
Population density	low	188	**0. 629**	**590.3**	**54.7**	10.1
	high	413	**0. 658**	**667.7**	**64.5**	12.0
Host plant	oak	422	0. 647	642.9	58.4	**12.0**
	beech	179	0. 639	615.2	60.8	**10.1**

The variants of the study variables with bold values are statistically significant at probability level 95%.

More northern populations (sector A) had a statistically significant lower average weight, but also a higher number of eggs per egg mass. Statistically significant hatching percentage in the following spring was lower, while the parasitism of the same egg masses was higher.

In the conditions of low population density, the statistical significance of the average mass and number of eggs per egg masses was lower than in the conditions of high abundance. The statistical significance of hatching percentage was also lower in the conditions of low population density; this factor had no effect on the percentage of parasitism.

Host plant had a significant effect only on the percentage of parasitism: it was higher in the egg masses collected in oak forests.

4. DISCUSSION

Many environmental factors such as climate, food quality, natural enemies, can affect the transfer of resources from parents to the progeny (Rossiter, 1994). Average weight of eggs in egg masses grows from the north towards the south. The research by other authors (Janković *et al*., 1959) show the same trend. On the contrary the average number of eggs per egg mass decreases from the north towards the south, i.e. the greater the number of eggs per egg mass, the lower the egg weight. Similar results were also reported by other authors (Lazarević *et al*., 1994; Shen *et al*., 2003). The larvae hatched from the smaller eggs, by the prolonged development time till the adult stage, compensate the advantage of the larvae hatched from the larger eggs. In this way, the progeny from the smaller eggs has the same size as that from the larger eggs (Fox *et al*., 1999). However, this leads to the longer exposure to the natural enemies, which has an adverse effect on the insect population dynamics. In many species, the supply of eggs with nutrients is the characteristic of plasticity, by which environmental conditions affect the trade-off between the egg size and number. In such cases, the adaptive changes and the allocation of resources to the progeny, under variable environmental conditions, can be considered as a form of flexibility in progeny planning (Rossiter, 1994).

As the less dense populations produce more fertile females (Zečević, 1976) we expected the similar results. However, our research shows that the females from the populations with low density produce a lower number of lighter eggs, and their hatching percentage is also lower. Also, we expected a significant difference in the percentage of parasitism between the different densities of the study populations. There are some differences but they are not statistically significant.

The diet conditions show that food quantity and quality in the previous generation affects the egg quality in the following generation. The quantity of the available food in the previous generation affects the protein content and the egg weight in the following generation (Rossiter *et al*., 1998). Consequently, host plant has a significant effect on egg weight (Capinera and Barbosa, 1977).

Our results do not show the differences between the host plants regarding egg weight, egg number and hatching. This can be the consequence of the migration of the older caterpillar instars from the oak forests to beech forests, to form pupae where the relative moisture is higher, i.e. where the conditions for this process are more favourable. It can be concluded that the caterpillars fed almost exclusively on oak foliage. Significant differences occurred only in the percentage of parasitism, which is higher in oak forests, which are a more xerothermic habitat. Such environmental conditions are more favourable to egg parasitoids, because they can develop a greater number of generations and thus attain the higher parasitism.

5. CONCLUSION

Geographic origin of the gypsy moth population has a statistically significant effect on the average egg weight, total number of eggs per egg masses, the hatching percentage and the parasitism percentage.

Population density has a statistically significant effect on the average egg weight, total number of eggs per egg masses and the hatching percentage, but it has not a statistically significant effect on parasitism.

Host plants from which egg masses were collected have a statistically significant effect only on the percentage of parasitism of eggs in egg masses.

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THRESHOLDS OF HARMFULNESS OF THE GYPSY MOTH CATERPILLARS FOR THE SPECIES *QUERCUS CERRIS* L., *QUERCUS ROBUR* L. AND *QUERCUS PETRAEA* (MATT.) LIEBL.

Slobodan MILANOVIĆ[1]

Abstract: *The degree of leaf mass damage depends on the absolute population density (abundance), i.e. on the number of gypsy moth caterpillars per 1000 leaves. If the absolute population density is higher, the greater percentage of damage can be expected. In addition to population density, the defoliation degree depends also on the sexual index. Due to the high sexual dimorphism, which is reflected in a greater number of female larval instars, the consequence is also the greater destruction of leaf area by female caterpillars. The loss of increment starts under the defoliation of 40%, the damage of 60% causes the development of the new leaves on the infested trees. If the defoliation is 100%, the site capacity for gypsy moth is saturated and their migration to the surrounding uninfested areas is possible. The thresholds of harmfulness for the species Q. cerris, Q. robur and Q. petraea are presented, i.e. the numbers of gypsy moth caterpillars per 1000 leaves which lead to a determined loss of leaf mass percentage for the analysed oak species. In the calculation of thresholds of harmfulness, sexual index is also taken into account. The determined thresholds of harmfulness for gypsy moth caterpillars for the analysed oak species can have a practical application in making decisions on the measures of air suppression in the infested forest complexes.*

Key words: *Q. cerris*, *Q. robur*, *L. dispar*, thresholds of harmfulness

1. INTRODUCTION

Basic factors which determine the gypsy moth presence and limit its range are, by all means, the climate and food. The area of the Balkan Peninsula is especially favourable for its development, whereas in the countries of Central Europe, it occurs more rarely and makes less damage (Janković, 1960).

The gypsy moth does not cause equal damage throughout its range. In our country, it can be found in all regions, up to the elevation of 1600 m on Kopaonik (Janković, 1954), but it is not considered an economically significant pest in the regions above 1000 m, because of the pronounced protogyny, the outbreaks last 2 to 3 years and there is no significant damage (Janković, 1954).

During the period 1862 - 1995, there were 16 outbreaks of the gypsy moth (Marović *et al.*, 1998). Some of them had catastrophic proportions. Thus, for example, during the outbreak in the period 1995 – 1999, the gypsy moth attacked the area of about 500,000 ha of forests and orchards (Mihajlović *et al.*, 1998). Now the 17th outbreak, which started in 2002, is under way. In the autumn 2004, the gypsy moth egg masses spread on the area of 360,000 ha of forests (Tabaković-Tošić, 2005).

The gypsy moth is a highly polyphagous species which feeds on the foliage of more than 500 tree and shrub species (Lance, 1983). According to the research (Janković, 1958), its optimal development is on the species from the genus *Quercus*. The most favourable species reported by

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Maksimović, 1997 are common oak and Turkey oak. In Serbia, there are ten species of deciduous oaks (Stojanović and Krstić, 2000).

In addition to the study of the relationship between insects and plants and their mutual effects, from the economic aspect, for production planning, it is necessary to study the potential levels of damage depending on the population density of the herbivore on its major host plants. For this reason, it is necessary to determine the critical numbers and thresholds of harmfulness, which vary depending on the host plant, just as the other parameters related to the gypsy moth development.

The prognosis of the outbreak occurrence and development requires a good knowledge of ecology and population dynamics of the insect species. This means the elaboration of very complex models with a great number of factors which affect the pest population dynamics, whose development lasts sometimes more than 10 years. Still, very often the prognosis of the outbreak occurrence and development cannot be predicted because the estimate depends on numerous factors which are interdependent. The deviation of only one parameter of the modelled algorithm leads to a series of changes of other input factors and to a wrong prognosis. For this reason, the simple models are much more efficient than the complex ones (Berryman, 1991), particularly if their purpose is the damage prognosis during different outbreak phases.

Short-term forecasts aimed at the assessment of the damage proportion are based on the damage thresholds and critical numbers. The gypsy moth critical numbers can be estimated in the egg stage and they are expressed as the number of eggs per tree, taking into account the tree age (Tropin cit., Group of authors, 1981). Vasić and Janković (1957) determine the critical numbers as the numbers of egg masses per tree, taking into account the age of the forest. Androić (1980) estimates the critical numbers of caterpillars per tree, taking into account the diameter at breast height. Patočka (cit., Mihajlović, 1986) estimates the critical numbers of caterpillars, i.e. the number of caterpillars per 1000 leaves. Mihajlović (1986) reports the advantage of this method in the forecasts of damage caused by early-season oak defoliators, because it is possible to determine both the qualitative composition of the population and the presence of natural enemies. The same author also determined empirically on individual trees, the critical numbers of caterpillars per 1000 leaves for common oak (438.2) and pubescent oak (344.6). By the assessment of the abundance of defoliator caterpillars on a series of trees with different degrees of defoliation, he concluded that common oak defoliation can be caused by 200 to 400 caterpillars per 1,000 leaves and pubescent oak defoliation can be caused by 150 to 350 caterpillars. For both species, the first visible damage i.e. the crown thinning occurs at the rate of about 100 caterpillars per 1000 leaves.

The assessment of critical numbers and thresholds of harmfulness in this paper is based on the method reported by Patočka (cit., Mihajlović, 1986). The thresholds of harmfulness and critical numbers are determined for each oak species separately, taking into account also the sexual index.

The number of caterpillars per 1000 leaves is determined directly in the field and the sexual index can be estimated based on the qualitative and quantitative indicators which determine the phase of the outbreak. Each outbreak phase is characterised by a definite range of sexual index. Vasić and Janković (1957) report that sexual index of 0.48 in 1955 dropped down to 0.17 in 1957. Some authors determine the sexual index based on the population density (Mauffette and Jobin, 1985) i.e. by the regression analysis which represents the dependence of the percentage of males in a population on the quantity of excrements, or the number of identified caterpillars below the tree canopy.

2. MATERIAL AND METHODS

In the experiment with variable environmental conditions, the foliage was scanned before and after the caterpillar feeding by laser scanner, resolution 200 dpi in jpg format. Later on, the daily consumed leaf area was calculated by using ***Image tool*** software package. The total area consumed by one caterpillar during its development was obtained by adding the calculated values.

Based on the analysis of the leaf area used in the experiment, their average values for each study oak species were calculated.

By the division of the total consumed area for each caterpillar separately, by the average leaf area in the experiment for the study oak species, the numbers of the consumed leaves during the development were calculated for all combinations of oak and sex.

The thresholds of harmfulness were determined based on the following criteria:

40% defoliation – results in the increment losses which increase proportionally with the increase of defoliation.

60% defoliation – results in the secondary leafing; the new leaves are susceptible to infestation by oak mildew, which increases the damage caused by the gypsy moth defoliation.

100% defoliation – the site capacity is exhausted and this may result in the migration of caterpillars to the surrounding non-infested areas (active spreading of the gypsy moth population).

3. RESULTS

The average leaf area of all the study oak species was calculated by processing all the leaves applied in the experiment. The average leaf area of Turkey oak in the experiment was the greatest and it amounted to 4,545.49 mm^2. The average common oak leaf area was 4,500.62, and sessile oak – 3,748.04 mm^2.

Table 1 presents the functions that describe the dependence of the absolute gypsy moth population density on sexual index, under the definite thresholds of harmfulness for the study oak species. The functions were obtained by the regression analysis and they make it possible for any sexual index to determine the number of caterpillars which will cause the defined damage threshold.

Table 1. Functions of the thresholds of harmfulness for the study oak species

Oak species	Thresholds of harmfulness		
	40%	60%	100%
Q. cerris	y = 2.2107x + 25.566	y = 3.316x + 38.349	y = 5.5267x + 63.915
Q. robur	y = 1.1607x + 22.97	y = 1.741x + 34.455	y = 2.9016x + 57.426
Q. petraea	y = 1.4776x + 25.535	y = 2.2163x + 38.302	y = 3.6939x + 63.837

y – number of caterpillars /1000 leaves

x - sexual index

Under the theoretical value of sexual index equal to 1, which never occurs in the field, the number of caterpillars per 1000 leaves necessary to cause 40% defoliation of Turkey oak is 27.8. Under the same value of sexual index, 41.7 caterpillars cause 60%, and 69.4 caterpillars cause 100% defoliation. If sexual index is 0, i.e. if only the males are present in the population (theoretical possibility) 40% defoliation is caused by 72.0 caterpillars. 108.0 caterpillars can cause 60% defoliation and 180.0 caterpillars are necessary for 100% defoliation.

Under the extreme value of sexual index equal to 1, 24.1 caterpillars per 1000 leaves of common oak cause the damage level of 40%. Under the same value of sexual index, 36.2 caterpillars cause the damage level of 60% and 60.3 for 100% defoliation. On the other hand, if only the males were present in the population (sexual index = 0), 47.3 caterpillars per 1000 leaves are necessary for the damage level of 40%. 71.0 caterpillars cause 60%, and 118.3 caterpillars per 1000 leaves cause 100% defoliation.

As for sessile oak, if sexual index is 1, 27.0 caterpillars per 1000 leaves cause 40%, and if sexual index is 0, 56.6 caterpillars cause the damage level of 40%. The defoliation of 60% is caused by 40.5 (sexual index 1), i.e. 84.8 caterpillars (sexual index 0), respectively. The complete defoliation is caused by 67.5 (sexual index 1), i.e. 141.4 caterpillars (sexual index 0).

4. DISCUSSION

The reduction in CO_2 fixing and leaf loss, if a low number of insects feed on a tree, is neglectfully low. However, when an enormous number of the winter moth and leaf rollers (or the gypsy moth) caterpillars infest an oak tree, the growth of the entire plant is seriously disturbed (Osborne, 1973). This indicates that the phytophagous insects can have a regulatory role in the growth and economy of host plants, so if intensified feeding is observed in the spring, the potential plant production becomes the function of the degree of the infestation. Consequently, it is necessary to estimate the defoliation degree depending on the infestation intensity, and in the function of identifying the economicity of pest control.

The defoliation percentage depends on the absolute population density (abundance), i.e. on the number of caterpillars per 1000 leaves. The higher the absolute population density, the higher the defoliation percentage can be expected. In addition to population density, the damage degree also depends on the sexual index. The consequence of a high sexual dimorphism, which is reflected in the greater number of female larval instars, is the greater destruction of leaf area by female caterpillars. Also, sexual index decreases during the outbreak (Vasić and Janković 1957), i.e. the number of males increases in the part of the population which terminates its development. It means that, at the same absolute population density, at the end of the outbreak when sexual index is lower, the defoliation intensity is lower than at the beginning.

5. CONCLUSION

The determined thresholds of harmfulness for gypsy moth caterpillars for the analysed oak species can serve as the criterion for the definite decision on the measures of air suppression in the infested forest complexes. It is recommended to determine the gypsy moth population density directly before the suppression to be able to determine the risk in the concrete area. Sexual index, as the other input parameter, along with the gypsy moth caterpillar number per 1,000 leaves, for the formulae defined in this study, can be calculated by regression analysis based on the collected quantity of excrements, or by the number of caterpillars found below the tree canopy.

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YIELD OF THE FUNGUS *PLEUROTUS OSTREATUS* (*JACQ. EX FR.)* KUMMER ON THE INOCULATED POPLAR STUMPS

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Abstract: *The yield of the fungus Pleurotus ostreatus (Jacq. ex Fr.) Kummer was researched on the inoculated poplar stumps in artificially established plantations. The inoculation of 27 stumps was performed in October with the prepared pleurotus mycelium. The first carpophores appeared in the autumn of the following year on 13 stumps. The carpophores were removed from the stump and their mass was measured. The average yield of oyster mushrooms was about 610 grams per stump, i.e. 1.814 kg/100 kg stump (substrate).*

As the results of this research refer to the yield during the first year, and as according to the previous research, the cycle of pleurotus cultivation on poplar stumps lasts for three years, it can be expected that the yield will exceed 3.5 kg per stump. This expected yield accounts for 11 % of the stump mass.

In addition to the yield, the significance of pleurotus cultivation on soft broadleaf stumps is in the fact that, the cost of stump chipping can be avoided by stump decomposition. This cost accounts for a significant percentage of the costs of plantation establishment. The decomposition process is relatively long and it can be implemented only in the specific conditions. The costs of stump chipping were also investigated, as well as the receipts realised by the utilisation of chips or the compact stump mass.

Key words: nonwood products, pleurotus, wood value, yield, cultivation, stump chipping, chipping costs, chipper.

1. INTRODUCTION

Despite the fact that the harvesting of nonwood forest products is becoming increasingly significant, wood is still the most significant product. It is supposed that in future the significance of wood will be lower on the account of nonwood forest products, but it will be a long process consisting of a great number of factors (sociological-economic, etc.) which affect the attitude to the forest and its products. The information on the economic significance of nonwood products is often deficient and unavailable. Therefore, it is very important to investigate the demand for nonwood products and the available potentials. Forests offer various products which can be harvested and one of them is mushrooms. In Serbia, the use of edible mushrooms is at a very low level and, according to some sources, our consumption is classified among the lowest in Europe. According to the available references, there are about 2,000 species of edible mushrooms, but very small number is commercially harvested (about 20). Thanks to the abundant and cheap material on which *Pleurotus ostreatus* (Jacq. ex Fr.) Kummer can be cultivated, fast growth and low investments, its production is increasing from year to year. In 1996, it reached 900,000 tons and it holds the second place in the world in the total industrial production of mushrooms.

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After tree felling, oyster mushrooms can be used for the decomposition of stumpwood both in natural and in artificial stands. In artificially established plantations of soft broadleaves, its significance is higher, because it is necessary to remove the stumps from the area for plantation establishment. The stumps can be removed manually or by machines. In modern times, this is done by stump pulling and stump chipping machines. The percentage of stump chipping costs in the total production costs is significant. The wood obtained by stump pulling and chipping (stumpwood) is most often used as fuelwood, and it has its market value. After stump chipping, the wood is utilised, but a quantity of finer chips remains on the ground and is subject to decomposition. One of the methods of removing the stumpwood in a short time is its decomposition by wood rotting fungi. This process is long lasting and cannot be applied in all cases, primarily when intensive plantations are established, which includes all agroengineering measures. The remaining stumps are an obstacle to the coarse and fine soil tilling, as well as to plantation tending. However, in all other cases, this method can have more advantages than the mechanised method.

2. MATERIAL AND METHOD

The pure culture of the fungus *Pleurotus ostreatus* was propagated on malt extract agar culture medium. The mycelium fragments from Petri dishes were inoculated on the sterilised wheat grains in the test tubes.

The boiled and well-drained wheat grains, with added mixture of gypsum and calcium carbonate, were placed in clean jars and sterilised at 112°C for one hour. After the grains were cooled in sterile conditions, the wheat grains previously coated with pleurotus mycelium in the test tubes, were added. The jar was kept in a thermostat at 22°C. After 20 days, after the mycelium had grown in the grains, the jars were kept in the refrigerator at the temperature of 2–5°C.

After tree felling, a disk 5-7 cm thick was cut from the stump. On the stump, several cuts were made with a power saw, about 3 cm deep, for mycelium plugs. The previously crushed mycelium was placed on the stump surface. The disk was replaced and nailed at several points. One litre of mycelium was sufficient for the inoculation of average four stumps. The stumps were not covered, because they were partly shaded, and the water level in the soil was high.

A year after inoculation, the carpophores were harvested from the stumps and their mass was measured. The yield was measured on 13 stumps.

The correlation between the yield and stump diameter, and between the yield and stump mass was calculated by regression analysis. Daily costs were calculated by standard calculations, and the outputs of stump chippers were taken from the book of technical norms (Nikolić S., Jezdić D., 2003).

3. RESULTS AND DISCUSSION

The process of pleurotus mycelium production in laboratory lasts for four to seven weeks. The isolation and propagation of pure culture lasts for about ten days. Figure 1 shows pure culture. The grains in the test tube are coated in about seven days. The test tubes with coated wheat grains are shown in Figure 2.

The coated wheat grains are then transferred in jars and after two to three weeks, mycelium grows the grains (Figure 3) (The jar in the left). If the jar is not refrigerated, mycelium continues growing in the grains, it becomes older and more compact, which makes the inoculation more difficult.

The mycelium of oyster mushrooms is usually produced in the laboratories in specially separated compartments for individual technological phases. According to Maksimović and

Figure 1. Pure culture of P. ostreatus

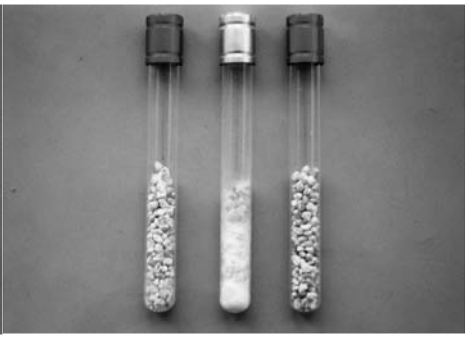


Figure 2. Mycelium coated wheat grains

Figure 3. Produced pleurotus mycelium

Wheat grains in the jar (on the right) are too much grown with mycelium. The inoculation with such mycelium should be avoided (mycelium is old and grows more slowly in the substrate, which increases the consumption of mycelium necessary for the inoculation).

Polak (1998), production starts by cutting a section from the fungus tissue or its spores. The other method is simpler and shorter, so it is more used nowadays.

The oyster mushroom spores are collected from the almost mature fruiting bodies. The fruiting body is washed with running water, taking care not to wet the lamellae. The fruiting body is placed onto a sterile Petri dish with gills turned down. In a day or two, below the fruiting body on the bottom of the dish, there is spore print, which is then transferred to the culture medium.

If a pure culture is made from the fungus tissue, the fruiting body is first washed with distilled water. Then, in sterile conditions, with a scalpel, a piece of the fruiting body is cut above the lamella, volume ≈ 5 mm^3. The piece of the fruiting body is then put onto the culture medium, most often malt extract agar.

If the mycelium is old, it should be tested. Several coated grains are placed on the sterile Petri dish with filter paper. After they are sprinkled with water, the Petri dish is covered and kept at the temperature between 22 and 25°C. If the small white hyphae about 5 mm long appear on wheat grains in two to three days, the mycelium can be used. In the opposite case (absence of hyphae), mycelium is old and should be discarded.

Today, almost all laboratories produce mycelium exclusively on cereal grains. The produced mycelium is measured by volume. As the data in the literature are often in kilograms, it should be noted that 1 litre of mycelium weighs 400–600 grams.

In addition to cereal grains, pleurotus mycelium can be produced on numerous other materials. In the past, the cut straw was used and maize stalks and cobs, but on it, mycelium soon lost the regeneration capacity. Straw can be used in combination with wood chips and cereal grains and in this case 60% is wheat straw, 20% poplar chips and 20% a cereal

The inoculation of 100 kg of the substrate requires about 3 litres of mycelium. Exceptionally, 5 litres of mycelium are used in the method of quick soaking, after quick cooling of the substrate and treatment with fungicides (benomil, enovit). One litre of mycelium can inoculate 5 – 10 stumps, diameter 20 – 40 cm.

3.1. Inoculation of stumps and the yield of oyster mushrooms

Poplar stumps were inoculated in October and altogether 27 stumps were inoculated. By a later inspection, it was found that during log extraction, the disks were removed from eight stumps, so the mycelium was dry.

Figure 4. A stump with formed pleurotus fruiting bodies

Figure 5. Yield on one of the stumps (fruiting bodies of different ages)

The appearance of the first carpophores was observed in the autumn of the following year (Figure 4). The carpophores were harvested from the stump (Figure 5) and their mass was measured. The yield of only 13 stumps was measured, because six stumps were under water because of the high level of the Danube.

Table 1 presents the yield of oyster mushrooms in the first fructification cycle.

Table 1. Pleurotus yield on the stumps of poplar Populus×euramericana 'I-214'

No.	Middle diameter (cm)	Stump height (cm)	Stump volume (m3)	Stump mass (kg)	P. body mass (g)	Yield (kg/100 kg wood
1.	55,90	24,4	0,0598	31,19	535,6	1,717
2.	60,15	24,3	0,0690	35,99	803,2	2,232
3.	58,65	25,2	0,0680	35,46	562,7	1,587
4.	50,40	25,5	0,0508	26,49	250,2	0,944
5.	57,45	24,7	0,0630	32,85	528,5	1,608
6.	59,70	23,9	0,0669	34,89	696,5	1,996
7.	54,30	25,3	0,0585	30,51	458,6	1,503
8.	58,50	24,8	0,0666	34,73	580,8	1,672
9.	65,45	24,1	0,0810	42,24	796,2	1,884
10.	58,40	23,8	0,0638	33,27	623,2	1,872
11.	58,75	26,4	0,0715	37,29	980,4	2,629
12.	55,90	24,8	0,0608	31,71	825,6	2,604
13.	53,85	25,6	0,0583	30,40	286,2	0,941
AVERAGE VALUE				33.62	609.8	1.814

The average pleurotus yield was about 610 grams per stump. If the yield is compared to the stump (substrate) mass, the value amounts to 1.814 kg/100 kg. Based on the reference data, at least two fructification cycles should be expected in the following period during a season. A better yield should be expected during the second and the third years. If it is supposed that the yield in the following period will be like this (without the increase in the second and the third years), the expected yield can be above 3.5 kg per stump. This expected yield would account for 11% of the stump mass. In his comment on pleurotus yield, Koso (1986) reports that the average yield accounts for 10% of stump mass, but he does not specify the tree species.

Maksimović and Polak (1998) present the data on the higher yield, i.e. 100 kg of wood in four years can produce the yield of 20 – 25 kg. Our expected yield in the period of three years should be about 11 kg per 100 kg of wood.

Diagram 1 presents the dependence of the yield on stump diameter. Figure 2 presents the dependence of fungus mass on stump mass. In both cases, there is a very strong correlation between the variables (Table 2).

Table 2: Statistical elements of the adopted functions

N. pr.	Funkcija	a	b	r	R2	Sx	F
Dp	$P = \exp(a + \frac{b}{D_P})$	11,35	-286,31	- 0,794	63,03	0,253	18,75
Mp	$M_b = \frac{1}{(a + b \cdot M_P)}$	0,0076	-0,00017	- 0,745	55,47	0,0006	13,70

Diagram 1. Correlation between the yield and stump diameter

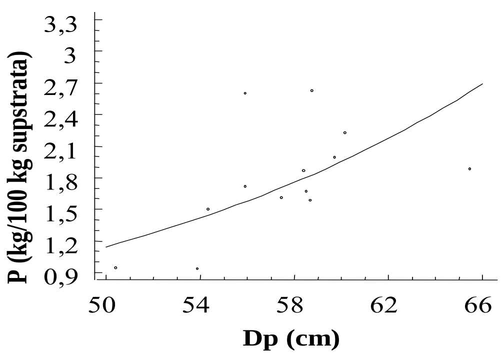
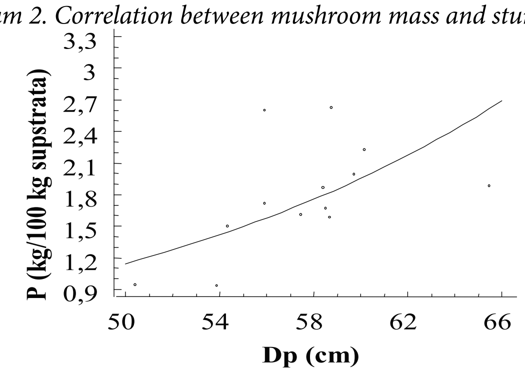


Diagram 2. Correlation between mushroom mass and stump mass



The results of the above research should be taken as approximate, because the yield is affected by a great number of factors. A greater yield is mainly achieved on hard wood than on soft wood and the fungus life cycle is considerably longer. The cycle of pleurotus cultivation on poplar wood is three years, and on beech wood it is seven years. The maximum pleurotus yield, after Terpo-Rimoczi (1975, cit. Koso 1986), is achieved on beech wood and Turkey oak. The yield depends also on the conditions on which the fungus is cultivated. The favourable air temperature and humidity, with the sufficient moisture of wood substrate, increase the yield. If the winter is mild, a new fruiting period can be expected. Also, the yield depends on the selection of the strain.

In pleurotus cultivation on straw, according to Koso (1986), the expected yield ranges between 10 and 25 kg of fresh mushrooms per 100 kg of wet substrate. Exceptionally, the yield can reach 30 kg per 100 kg of wet substrate.

In the laboratory research, most authors use the term biological productivity to describe the yield of mushrooms. Biological productivity is the ratio of the mass of fresh mushrooms and the mass of the dry substrate, in %.

Ginterová *et al.* (1982), in the study of the effect of different substrates on the yield, reports that the maximum yield (79 %) was attained on bean straw, and the minimal on crushed maize cobs (34.5%). The yield on wheat straw accounted for 38%. During the study period (70 days), pleurotus fructified on bean straw seven times, on crushed maize cobs four times, and on wheat straw three times. Puri *et al.* (1981) cultivated *Pleurotus fosulatus* on wheat straw and rice straw, and achieved the yield of 30–40%.

Veselinović and Peno (1985) report the yield of 69% achieved in three waves on poplar sawdust without bark. By adding gypsum and calcium-carbonate to this substrate, the yield decreased up to 20%, the number of carpophores was lower but they were larger and of better quality. On the sawdust of poplar with bark, the yield accounted for 50%.

Royse and Schisler (1987) achieved the yield of 42% in the cultivation of *P. ostreatus* on wheat straw. The yield of 37% was achieved for *P. sajor-caju* on the same substrate. The same authors report that, by adding the commercial preparation (Spawn Mate II) to the straw, they achieved the increase of the yield of *P. ostreatus* by 85%, and *P. sajor-caju* by 73%.

Generally, Zadražil and Grabbe (1983) report that the yield of all cultivated species (and strains) depends on the genetic potential, physical and chemical characteristics of the substrate and on the environmental factors. The most important physical properties of the substrate are moisture, porosity and the size of the particles. The important chemical parameters of the substrate are the presence of polysaccharides, lignin, proteins, carbohydrates, mineral substances and nitrogen. The pH value of the substrate is also very important. Of the environmental conditions, the most important are the temperature, air humidity, oxygen and CO_2 ratio, and the light.

3.2. Labour cost of stump chipping

In soft broadleaf plantations, stump chipping is one of the very significant jobs. According to Đoković, Marković, 1983, these costs account for between 15 and 23% of the costs of plantation establishment, tending and protection, or for 8% of the total costs of production of the product unit. Taking into account the status of the machinery and the chipping costs, in a great number of plantations in Serbia, the stumps are not chipped, and they are left on the ground to rot. This is particularly the case in the flooded area (marshes) where agroengineering measures (ploughing, disking, etc.) are often left out. Planting is done between the stumps, and tending is reduced to hoeing around the seedlings and to pruning. In the intensive plantations, stump chipping is a necessary measure. In the last years, this job has been completely mechanised, which leads to the lower percentage of manpower, greater outputs, i.e. to significantly lower costs of wood production in intensive plantations. Chipping is performed by different types of stump chippers and stump pullers (Levaceppi Ellettari, Rotor Cavaceppi, Tritaceppi Ellettari, etc.) which are aggregated with tractors of the corresponding power. One of such devices is presented in Figure 4.

Figure 4. Stump chipper

The daily direct costs of stump chipper operation are presented in Table 3. The daily costs were calculated by the standard calculations.

Table 3. Daily costs of chipper work

Calculation		
Remaining value (P)	EUR EUR·year-1 h ·year-1	25000.00
Annual depreciation (Ai)		16666.67
Average annual investment (PGI)		83333.33
Productive machine hours per year (PHS)		1600.00
Costs		
Interest (K)	EUR·year-1	8333.33
Insurance and taxes (TOS)		3333.33
Annual costs (Ah+ K + TOS)		28333.33
Fuel costs (TG)	EUR·h -1	2.06
Lubricant costs (TM)		0.76
Repairs and maintenance (TOD)		3.13
Compensation for work and retirement insurance (LD)		5.25
Total costs	EUR· SMH-1	23.12
	EUR· PMH-1	28.90
	EUR· day-1	184.96

According to Danilović, Tomašević, 2000, the outputs achieved by the machines in soft broadleaf stump chipping depend on several factors (stump diameter, spacing between stumps, manpower capacity, etc.).

Based on the average time spent on chipping one stump (*min·piece^{-1}*), the daily outputs of Ellettari aggregated with tractor Elefante are presented in Table 4 (Danilović, Tomašević, 2000). The outputs are expressed by the number of stumps of a given diameter per work day. Unit costs are the quotient of daily costs and outputs (Table 4).

The costs of stump chipping increase significantly with the increase of stem diameter. The correlation between variables is complete and can be represented by a linear function. Total costs of stump chipping in this research amounted to € 12.73. These costs can be increased by transport costs. The value of stumps, according to SE "Srbijašume" price list, is € 8.8, i .e. without transport costs, the difference is about € 4. It should also be emphasised that a part of stumpwood remains unutilised, so the income should be reduced by that quantity. In this case, the difference between income and costs will be greater.

Table 4. Costs of soft broadleaf stump chipping

No.	Mean diameter (cm)	Stump vol. (m3)	Stump mass (kg)	Stump price (EUR·m-3)	U (pcs·day-1)	ti (EUR·pcs-1)
1.	55,90	0,0598	31,19	0,628	193	0,958
2.	60,15	0,0690	35,99	0,725	183	1,011
3.	58,65	0,0680	35,46	0,714	186	0,994
4.	50,40	0,0508	26,49	0,533	208	0,889
5.	57,45	0,0630	32,85	0,662	189	0,979
6.	59,70	0,0669	34,89	0,702	184	1,005
7.	54,30	0,0585	30,51	0,614	197	0,939
8.	58,50	0,0666	34,73	0,699	186	0,994
9.	65,45	0,0810	42,24	0,851	171	1,082
10.	58,40	0,0638	33,27	0,670	187	0,989
11.	58,75	0,0715	37,29	0,751	186	0,994
12.	55,90	0,0608	31,71	0,638	193	0,958
13.	53,85	0,0583	30,40	0,612	198	0,934
	57,5	0,0645	33,62	0,677		0,979
Σ		0,838	437,02	8,8		12,73

4. CONCLUSION

The following conclusions can be made based on the study results:

- The laboratory process of pleurotus mycelium production, necessary for stump inoculation, lasts for four to seven weeks. The isolation and propagation of the pure fungus culture requires about ten days. The grain covering in the test tube lasts for seven days, and the mycelium grows in the grains in the jar in two to three weeks.
- The average yield of oyster mushrooms was about 610 grams per stump, i.e. 1-814 kg/100 kg of substrate. According to references, a higher yield should be expected during the second and the third years. If they are taken as representative and transferred to the total period of fructification (without the increase in the second and the third years), the yield of more than 3.5 kg per stump or 11 % of stump mass can be expected. These values should be taken as approximate, because the yield is affected by numerous factors (climate conditions, wood substrate moisture, selection of mushroom strain, etc.).
- The correlation of the yield and stump diameter, as well as of mushroom mass and stump mass is very strong.
- In soft broadleaf plantations, stump chipping is one of the very significant jobs. Based on the previous research, the costs of stump chipping account for 8% of the total costs of production. Taking into account that the status of the machinery in Serbia is unsatisfactory, the stumps are not chipped in many plantations, although it is necessary. This is particularly the case in the flooded area (marshes) where planting is done between the stumps, and tending is most often reduced to hoeing around the seedlings and to pruning.
- The stump decomposition by wood rotting fungi can be applied in the cases where the complete cultivation technology is not planned.
- The outputs realised by the machines in stump chipping of soft broadleaves depend on several factors (stump diameter, spacing between stumps, operator capacity, etc.).
- Stump chipping costs increase significantly with the increase of stem diameter. The correlation of the variables is complete and can be represented by a linear function.

- Total costs of stump chipping in this research amounts to € 12.73, and the value of stumpwood is 8.8 EUR. The difference between income which can be earned by selling stumpwood and the costs (without transport costs) is about 4 EUR. The difference depends on the percentage of stumpwood utilisation.

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INTERACTIONS OF THE FUNGUS *PLEUROTUS OSTREATUS* (JACQ. EX. FR.) KUMMER AND SOME POPLAR WOOD-ROTTING FUNGI

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Abstract: *The fungi Trametes hirsuta, Schizophyllum commune and Coriolus versicolor were isolated from poplar stumps planned for artificial cultivation of the fungus Pleurotus ostreatus. The aim of this study is to identify, in laboratory conditions, the behaviour of these fungi in the mixed cultures. Two isolates of the fungus Pleurotus ostreatus were used in the research. The results show that Pleurotus ostreatus in the mixed cultures does not tolerate the competition of the above species. For this reason, the artificial cultivation of pleurotus requires fresh stumps which are not infested by the above fungi.*

Key words: *Pleurotus ostreatus*, mixed cultures, reaction type, sensitivity index

1. INTRODUCTION

Pleurotus ostreatus is a very frequent mushroom species in broadleaf forests, but it is much rarer in coniferous forests. It occurs most often on beech and poplar and more rarely on oak, hornbeam, maple, birch and willow. Oyster mushroom often occurs in large groups on the stumps, on standing trees and felled logs. It is widely distributed throughout Europe, Asia, North Africa, America and Australia.

The most frequent species of epixylous fungi reported by Marinković *et al.* (1983), occurring on poplars are the following: *Fomes fomentarius*, *Trametes suaveolens*, *Chondrostereum purpureum*, *Coriolus hirsutus* and *Schizophyllum commune.* In addition, the following are reported as the potential destructive fungi: *Pleurotus ostreatus*, *Pholiota sqarosa*, *Pholiota destruens* and *Lentinus tigrinus.* During their one-year study, Tomović and Karadžić (1988) identified the following fungi on the cellulose poplar wood: *Cladosporium herbarum*, *Epicoccum purpurescens*, *Trichotecium roseum*, *Fusarium avenaceum*, *Penicillium* sp., *Cytospora chrysosperma*, *Coriolus versicolor*, *Coriolus hirsutus*, *Trametes suaveolens*, *Pleurotus ostreatus*, *Pholiota destruens* and *Stereum* sp.

The fungi *Schizophyllum commune, Trametes hirsuta* and *Coriolus versicolor* were isolated from poplar stumps planned for artificial cultivation of *Pleurotus ostreatus.* Their interactions in mixed cultures were researched because these species occur on tree species which are most often applied for oyster mushroom cultivation.

2. MATERIAL AND METHOD

During the inspection of the stumps planned for inoculation, the fruiting bodies of other fungi were observed on the neighbouring stumps. They were collected, brought to the laboratory and identified as follows: *Schizophyllum commune*, *Trametes hirsuta* and *Coriolus versicolor*. Pure cultures were isolated from the carpophores and the *P. ostreatus* carpophore found in Košutnjak (*P. ostreatus* K.). In the aim of testing the interaction of the fungi in mixed culture, the above

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isolates and the isolate of the mushroom *Pleurotus ostreatus* (P.O. 83) were synchronically sawn on the opposite sides of Petri dishes, by the principle of pairing. At the same time, individual fungi were sawn onto the control Petri dishes.

All Petri dishes were kept in the thermostat at the temperature of 23°C. After the period of adaptation, the rate of mycelium growth was measured daily. The radius was measured (in mm) three times, under the perpendicular angle of 22.5°. Along with the rate of mycelium growth, the mycelial interactions were also monitored, i.e. the contacts or the inhibition of growth of individual fungal colonies. We measured also the width of the zone by which one fungus replaces the other. The width of the zone by which one fungus replaces the other was measured only on the middle radius. If the fungi had no contact, we measured the width of the inhibition zone. The study results were presented by the method proposed by Ekstein and Liese (1970, cit. Mirić 2003).

Based on the study data, we calculated the average radius values of fungus colony grown individually (control Petri dishes) and the colony of the same fungus grown in the Petri dish paired with an antagonistic fungus. The Diagrams for each fungus show the values of the fungi growing individually and the values of the paired growth with an antagonistic fungus.

The Diagram is rotated about *x* axis for 180° and overlaid with the Diagram of the antagonistic fungus. The new Figure shows all the important moments of fungus growth (contact, inhibition zone width, replacement zone width,...).

Based on the above data, the sensitivity index for each fungus was determined according to the following criteria:

0 - growth not affected and halted before the contact with the antagonistic fungus;

1 - growth retarded and halted at contact;

2 - growth retarded and replaced after the contact;

3 - growth not affected and halted after the contact;

4 - growth not affected and replaced after the contact;

5 - growth stimulated before, and halted after the contact;

6 - growth stimulated before, and replaced after the contact;

7 - growth retarded and halted before the contact;

8 - growth stimulated and halted before the contact.

In the end, the reaction type of the antagonistic fungus was determined in the similar way:

I - both fungi have retarded growth and are deadlocked before the contact, forming the inhibition zone;

II - both fungi have retarded growth and are deadlocked at contact point;

III - one fungus has stimulated growth, the other has retarded growth, and both are deadlocked at contact point;

IV - one fungus has retarded growth and is deadlocked before the contact, the other has stimulated growth and replaces the antagonist after contact;

V – both fungi do not affect growth and are deadlocked at contact, or before the contact;

VI - both fungi have retarded growth before the contact, and at contact one is deadlocked and the other replaces it;

The above are only the most frequent indexes of sensitivity and reaction types occurring during fungal growth in mixed cultures.

3. RESULTS

The study results are presented in Figures 1-10, and the codes are as follows: **00** - *Pleurotus ostreatus* (P.O.83); **01** - *Pleurotus ostreatus* K.; **02** -*Schizophyllum commune*; **03** - *Coriolus versicolor*; **04** - *Trametes hirsuta*; **K** - control; **Is** - sensitivity index.

Figure 1. Type of reaction VI: 00 and 01

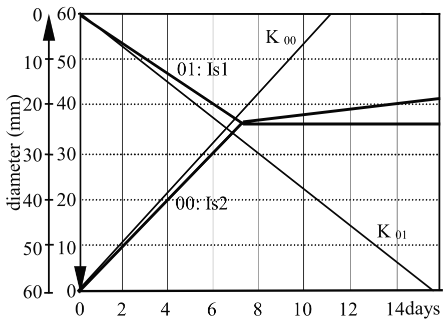


Figure 2. Type of reaction II: 00 and 02

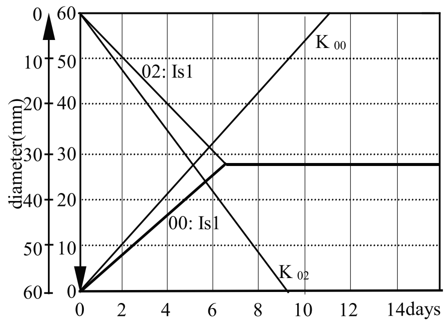


Figure 3. Type of reaction VI: 00 and 03

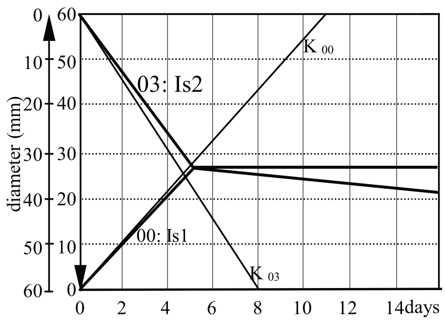


Figure 4. Type of reaction VI: 00 and 04

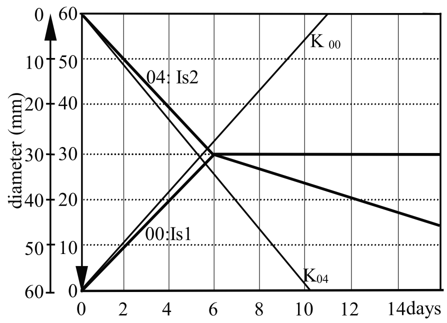


Figure 5. Type of reaction VI: 01 and 02

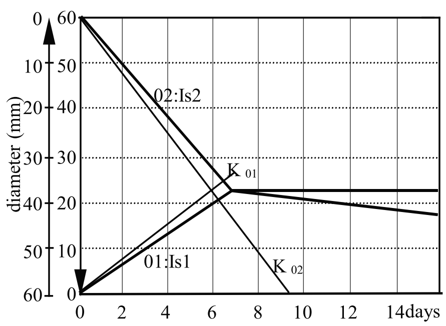


Figure 6. Type of reaction VI: 01 and 03

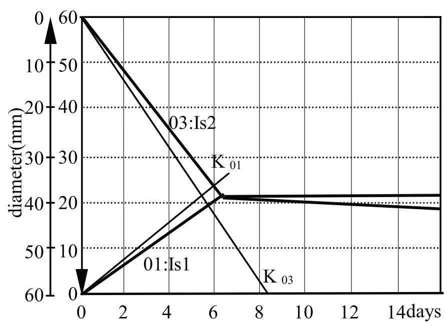


Figure 7. Type of reaction VI: 01 and 04

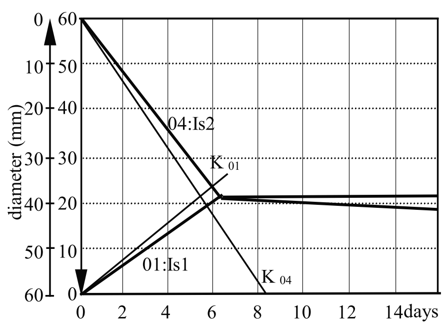


Figure 8. Type of reaction VI: 02 and 03

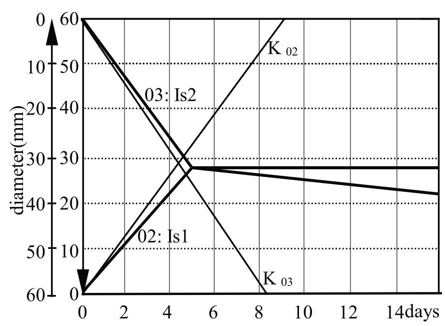


Figure 9. Type of reaction VI: 02 and 04

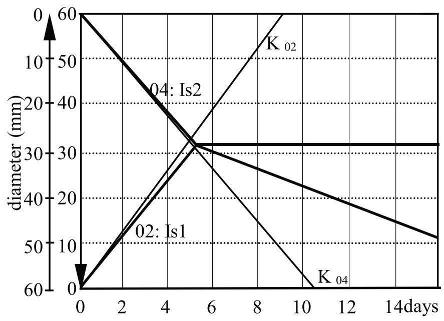
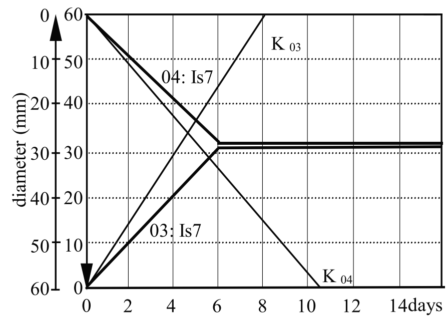


Figure 10. Type of reaction I: 03 and 04



Average daily growth of *P. ostreatus* in the control series is 5.55 mm, and *P. ostreatus* K 3.83 mm. In the mixed culture, *P. ostreatus* (P.O.83) isolate has sensitivity index 2, and isolate *P. ostreatus* K. has sensitivity index 1. The contact occurs after seven days. In the mixed culture, isolates *P. ostreatus* (P.O.83) and *P. ostreatus* K. have reaction type VI (Figure 1). After contact, the isolate from Košutnjak is deadlocked and replaced by the isolate P.O.83 in the following seven days, zone width about 5 mm.

Average daily growth of *P. ostreatus* in the control series is 5.55 mm, and *S. commune* 6.51 mm. In the mixed culture, both isolates grow slower than in the control series (Figure 2) and after the contact, the growth halts (Sensitivity index 1). The contact occurs between the sixth and seventh day. In the mixed culture, *P. ostreatus* and *S. commune* have reaction type II.

Average daily growth of *P. ostreatus* mycelium in the control series is 5.55 mm, and *C. versicolor* 7.4 mm. *P. ostreatus* grows slower than in the control series, and it is deadlocked after the contact (Is 1). *C. versicolor* also grows slower than in the control series, but after the contact it replaces the fungus *P. ostreatus* (Is 2). The contact occurs after the fifth day. In mixed culture, *P. ostreatus* and *C. versicolor* have reaction type VI (Figure 3). After contact, *P. ostreatus* is deadlocked and replaced by *C. versicolor* in the following nine days, zone width 4.76 mm.

Average daily growth of *P. ostreatus* in the control series is 5.55 mm, and *T. hirsuta* 5.9 mm. *P. ostreatus* grows more slowly than in the control series and after the contact it is deadlocked (Is 1), while *T. hirsuta* also grows more slowly than in the control series but replaces pleurotus after the contact (Is 2). The contact occurs between the fifth and six day. In mixed culture, *P. ostreatus* and *T. hirsuta* have reaction type VI (Figure 4). After contact, pleurotus is deadlocked and replaced by *T. hirsuta* in the following eight days, zone width 16.4 mm.

Average daily growth of *P. ostreatus* K in the control series amounts to 3.83mm, and *S. commune* 6.51 mm. In the same Petri dish, *P. ostreatus* K. has retarded growth and is deadlocked after the contact (Is 1). *S. commune* also has retarded growth, but after the contact, it replaces *P. ostreatus* K. (Is 2). The contact occurs between the sixth and seventh day. In mixed culture, *P. ostreatus* K. and *S. commune* have reaction type VI (Figure 5). After contact, *P. ostreatus* K. is deadlocked and replaced by *S. commune* in the following seven days, zone width 6 mm.

Average daily growth of *P. ostreatus* K. in the control series is 3.83 mm, and *T. versicolor* 7.4 mm. Under paired growth in the same Petri dish, *P. ostreatus* K. grows slower than in the control series and after contact, it is deadlocked (Is 1). Fungus *C. versicolor* also grows slower, but after the contact it replaces *P. ostreatus*.K. (Is 2). These two fungi contact on the sixth day. In the mixed culture, *P. ostreatus* K. and *C. versicolor* have reaction type VI (Figure 6). After contact, *P. ostreatus* K. is deadlocked and replaced by *C. versicolor* in the following nine days, zone width 3 mm.

Average daily growth of *P. ostreatus* K. in the control series is 3.83 mm, and *T. hirsuta* 5.9 mm. Under paired growth in the same Petri dish, *P. ostreatus* K. has sensitivity index 1 (growth retarded and deadlocked after the contact), and fungus *T. hirsuta* has sensitivity index 2 (retards growth and replaces the other fungus after the contact). The contact occurs between the sixth and seventh day. In mixed culture, fungus *P. ostreatus* K. and *T. hirsuta* have reaction type VI (Figure 7). After contact, *P. ostreatus* K. is deadlocked, and in the following seven days, it is replaced by *T. hirsuta,* zone width 4.4 mm.

Average daily growth fungus *S. commune* in the control series is 6.51 mm, and *C. versicolor* 7.4 mm. Under paired growth in the same Petri dish, *S. commune* has sensitivity index 1 (retards growth and deadlocked after the contact), and *C. versicolor* sensitivity index 2 (retards growth and replaces the other fungus after the contact). The contact occurs on the fifth day. In mixed culture, fungus *S. commune* and *C. versicolor* have reaction type VI (Figure 8). Fungus *S. commune* is deadlocked and replaced by *C. versicolor* is in the following nine days, zone width 4 mm.

Average daily growth of *S. commune* in control series is 6.51 mm, and *T. hirsuta* 5.9 mm. Under paired growth in the same Petri dish, *S. commune* has sensitivity index 1, and *C. hirsuta* has sensitivity index 2. The contact occurs on the fifth day. In mixed culture, fungus *S. commune* and *T. hirsuta* have reaction type VI (Figure 9). *S. commune* is deadlocked and replaced by *T. hirsuta* is in the following nine days, zone width 20 mm.

Average daily growth of *C. versicolor* in the control series is 7.4 mm, and *T. hirsuta* 5.9 mm. Under paired growth in the same Petri dish, both fungi have sensitivity index 7. On the sixth day, both are deadlocked and inhibition zone between them is 0.6 mm. In mixed culture, *C. versicolor* and *T. hirsuta* have reaction type I (Figure 10).

4. DISCUSSION

To avoid the misunderstanding in the description of interactions among the fungi, Rayner and Webber proposed a scheme in 1984, in which the terms are defined. According to them, interactions can be *competitive*, *neutralistic* and *mutualistic***.** In competitive interactions, one fungus can soon occupy the space of the other fungus (replace it), and the fungus is finally replaced despite its resistance, (it defends itself by the products of its metabolism).

There are three different types of reactions to the contact between somatic hyphae: hyphal fusion (anastomosis), hyphal interference, and parasitism (Rayner and Boddy, 1988). Genetically compatible hyphae fuse by collateral channels (anastomoses) and there are no visible changes in the appearance of the colony in the contact zone.

Hyphal interference leads to the destruction of the protoplasm in the contact zone, which can cause death of one or both hyphae of the paired fungi (Ikediugwa, Dennis and Webster 1970). Ultrastructural investigation reveals that the attacked parts of the hyphae have vacuolised nuclei and mitochondrion.

Hyphal parasitism is a typical mycoparasitic reaction leading to penetration, attachment, and also to the growth in the area of the parasitised hypha (Barnett and Binder, 1973).

In different mycelial interactions, the colony of one fungus sometimes cannot capture the space of the other fungus. This phenomenon is explained by the capacity of the fungus to release chemical substances before the contact, which spread through the substrate, or the mutual air space (Morton and Eggins, 1976; Bruce, Austin and King, 1984). In these cases, inhibition of the margin parts of the colonies is the consequence of the reduced hyphal branching and the vacuolisation of the margin hyphae.

The population structure of basidiomycetes is the result of sexual and somatic reproduction (mycelium fragmentation). In *P. ostreatus* hyphal fusion, migration of nuclei, their fusion and dikaryotic growth are controlled by two multiallele factors (A and B) (Shtaer, Belokon, Belokon and Shnyreva 2005). In the study of 58 fruiting bodies of *P. ostreatus*, the genetic compatibility was found in 8 % of cases.

The isolates of *P. ostreatus* (P.O.83 and *P. ostreatus* K.) are not genetically compatible. There is no hyphal anastomosing and paired growth, and the isolate *P. ostreatus* (P.O.83) replaces the isolate from Košutnjak. In his study of the fungus *Fomitopsis pinicola* variation, Lazarev (2001) found that sometimes also the mycelia of the fungi isolated from different parts of the same carpophore are genetically incompatible, so the zone of aversion is formed between them.

In the interaction of *P. ostreatus* with the agents of white rot in the confrontation zone, the synthesis of enzyme loccase and peroxidase is intensified (Tsujiyama and Minami 2005). They report seven types of interaction and the fungal dominance is classified as follows: *P. ostreatus* > *C. versicolor* > *P. coccineus* > *G. applanatum* > *S. commune*.

In our study, the fungi *C. versicolor* and *T. hirsuta* show a strong antagonism to *P. ostreatus* isolates, they halt its growth and replace it. Fungus *S. commune* halts the growth of *P. ostreatus* (P.O.83) and replaces *P. ostreatus* K.

5. CONCLUSION

Fungus *P. ostreatus* (P.O.83) has reaction type II only with fungus *S. commune,* and it has reaction type VI with other fungi. Of all the study fungi, *C. versicolor* has the lowest, and *S. commune* has the highest effect on the growth of *P. ostreatus* (P.O.83).

Fungus *P. ostreatus* K. has reaction type VI with all the analysed fungi. However, the effect of these fungi on mycelium growth of this isolate is very low. Thus *S. commune,* which has the greatest effect, retards its growth daily only by 0.53 mm.

Fungus *S. commune* has reaction type II only with fungus *P. ostreatus* (P.O.83) and it has reaction type VI with other fungi. The isolate *P. ostreatus* (P.O.83) has greatest effect on its growth, and *T. hirsuta* has the lowest effect

Fungus *C. versicolor* has reaction type I only with fungus *T. hirsuta*, and it has reaction type VI with other fungi. The fungus *P. ostreatus* (P.O.83) has the lowest effect on the growth of this fungus, and the fungus *T. hirsuta* has the highest effect. An inhibition zone is formed between *C. versicolor* and *T. hirsuta*.

Fungus *T. hirsuta* has reaction type I only with fungus *C. versicolor*, and it has reaction type VI with other fungi. The fungus *S. commune* had the lowest effect on the growth of this fungus, and *C. versicolor* had the highest effect. An inhibition zone is formed between *T. hirsuta* and *C. versicolor.*

The above results indicate that *Pleurotus ostreatus* does not tolerate the competition of the above species. For this reason, the presence of some of these fungi should be checked before wood (logs, stumps) inoculation. If the wood is infested, it should not be used for pleurotus cultivation.

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STRUCTURE AND HEALTH STATUS OF BEECH FORESTS IN MIDDLE BALKAN RANGE

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Abstract: *The growth and height structure was investigated in 5 type beech ecosystems and some fungi from Nectria genus, insect vector species as Cryptococcus fagy Barensp. and Ectoedemia liebwerdella Zim. They transfer necrotic diseases leading to damages of bark, increasing of rotting processes as well as decreasing of biological resistance in these stands.*

Key words: *Fagus sylvatica* L., height structure of stand, pathogenic fungi (*Nectria* sp.), stem damages

1. INTRODUCTION

As geobotanical situation Bulgaria is located in European deciduous region and the ecosystems investigated in Balkan Range are in its Illyrian (Balkan) province (Mishev, 1989).

The climate is moderate continental with average annual temperatures from 5 to 10.8° C and average annual precipitations from 830 to 1150 mm. The soils are Cambiosols (CM) with pH>5.2 formed on metamorphic cliffs, andesites, syenites and rhiolites, located on slope with predominant shadow (north) exposure type C and D.

During the last years the monitoring observations of beech ecosystems in Middle Balkan Range showed forced pathogenic processes related to the appearance of necroses (*Nectria* sp.) leading to worsening of the health condition and structure of these ecosystems (Rossnev, Petkov, 1996). The investigations of some European scientists (Lonsdale, 1980; Perrin, 1983; Lazarev, 1985; Cicak, Mihal, 2002) confirm these findings. The term 'necrosis on the bark' is related to a process of bark dead and it concaves, breaks, callus cavities appears damaging the conductive tissue.

This article aims at investigation on beech stem damages, fungi and insect species – vectors causing necroses and the contemporary structure of five beech stands in Middle Balkan Range.

2. OBJECT AND METHODS OF WORK

According to the forest vegetation regions (Zahariev et al., 1978) the objects are located in the Mizian region (sub region North Bulgaria in the low and middle mountain beech forests.

In table 1 is presented the ecological forestal characteristic of the 12 investigated beech dendrocoenosis with an average age from 60 to 130 years growing on north exposure with altitude from 450 to 1400 m. Five types beech forests were investigated (according to Penev et al., 1969) as follows: 12. Dolinna gorunovo-gabarova dabrava (SP8, SP11), 14. Sveja bukovo gorunova gora s gabar (SP1, SP2, SP5, SP7), 15. Bukova gora s kapina (SP6)., 16. Bukova gora sas swetlika (SP9, SP12) and Forest type 17. Bukova gora s lazarkinia (SP3, SP4, SP10), with no influence by pollution sources for the air and the invironmet.

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Table 1. Ecological and silvicultural characteristic of sample plots

Sample plot	Location	Altitude m, a.s.l	Mean annual t°	Mean annual precipi-tation	Soil type	Exposition	Composi-tion	Canopy	Mean			Forest type acc. to Penev et al. (1969)
				mm					Age	Height m	DBH,cm	
1	SGBS Vitinya Vitinya	970	5,0–6,0	1000–1050	Cambisols, CM (D2/3)	NE	F. sylvatica 10	0,6–0,7	90	25,0	39,5	14. Sveja bukovo-gorunova gora s gabar
2	SFE Botevgrad Pravets	700	6,0–8,8	930–1000	Cambisol, CM (C2)	N	F. sylvatica 10	0,7–0,8	50	19,0	20,9	14. Sveja bukovo-gorunova gora s gabar
3	UES Petrochan Petrochan	1400	5,0–6,0	1000–1150	Cambisols, CM (C2)	NE	F. sylvatica 10	0,7	100-110	24,0	39,4	17. Bukova gora s lazarkilia
4	UES Petrochan Barzia	1150	5,0–6,0	1000–1500	Cambisols, CM (C2)	N, NW	F. sylvatica 10	0,6	130	28,0	50,8	17. Bukova gora s lazarkilia
5	SEF Etropole Manastira	720	6,0–8,0	930–1000	Cambisols, CM (D2)	NE	F. sylvatica 10	0,5–0,6	120-130	27,0	40,6	14. Sveja bukovo-gorunova gora s gabar
6	SFE Ribaritsa	1010	5,0–6,0	1000–1150	Cambisols, CM (D2-3)	W, NW	F. sylvatica 10	0,6	60-70	22.0	19,3	15. Bukova gora s kapina
7	SFE Troyan Shipkovo	650	6,0–8,8	930–1000	Cambisols, CM (C2)	NE	F. sylvatica 10	0,8	70	25,0	23,9	14. Sveja bukovo-gorunova gora s gabar
8	SFE Troyan Kapintsho	480	8,8–10,8	800–930	Luvisols, Lv (CD2)	NE	F. sylvatica 10	0,8	90	26,0	24,5	12. Dolinna gorunovo-bukovo-dabarova dabrava
9	SFE Troyan Beklemeto	1300	5,0–6,0	1000–1150	Cambisols, CM C1,2)	E, NE	F. sylvatica 10	0,6	50-60	19,0	16,7	16. Bukova gora sas svetlika
10	SFE Troyan Balkanets	1250	5,0–6,0	1000–1150	Cambisols, CM (C2)	N	F. sylvatica 10	0,5	100-120	30,0	38,3	17. Bukova gora s lazarkilia
11	SFE Sevlievo Boaza	450	8,8–10,8	800–930	Luvisols, Lv (CD2)	N	F. sylvatica 10	0,7	70	21,0	19,8	12. Dolinna gorunovo-bukovo-dabarova dabrava
12	SFE Kazanlak Shipka	1100	4,9–7,0	830–960	Cambisols, CM C1,2)	E, NE	F. sylvatica 9, C.betulus 1	0,7	60	22,0	23,3	16. Bukova gora sas swetlika

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To precise the beech stands structure the classification of the trees by growth is used (Kraft, 1884). In its original appearance it defines the stems according to the supremacy and depression in five classes – dominant (the largest trees), co-dominant, medium depressed and dying (trees under the stand canopy), (according to Kostov, Nedelin, 1996). In the established sample plots 100 trees growing at rich areas I and II site class with different dendrometric indicators ($D_{1.30}$ and H) and growth status were observed.

The beech health condition was determined by Institute of Forest Ecology – Slovakia methodic, with beech stem damages (necroses, insect pests-vectors, mechanical damages, rotting and wood destroying fungi, frost damages) added.

3. RESULTS AND DISCUSSION

In table 2 is presented the summarized growth of the stand by age and height classes according to Kraft. In all age classes (from III to VII) the greatest is the participation of I height class trees – from 40% (SP 8) to 58.5% (SP 4 and 5). In the upper part of the stands' canopy dominant stems are 48.2% and those of II height class – 28.3%. The middle part of the canopy is formed by III class trees (form 7.5 to 18.2%).

Table 2. Beech Stands Structure According Height Class

Age class	Sample plot	Growth Class acc. to Kraft in %					DBH
		I	II	III	IV	V	
1	2	3	4	5	6	7	8
III	2, 9, 12	49,7	30,5	17,8	1,0	1,0	20,3
IV	6, 7, 11	42,0	36,8	18,2	2,3	0,7	21,0
V	8	40,0	50,0	10,0	–	–	24,5
VI	1, 3, 10	51,0	31,8	12,5	3,7	1,0	39,1
VII	4, 5	58,5	22,5	7,5	6,0	5,5	45,7
Mean value		4,2	28,3	13,2	2,6	1,6	

In the lower part of the canopy (IV and V growth class) the beech stems are with very low participation – from 1.0 to 6.0%. We should note that only in sample plot stands N 1, 2, 4, 5 and 6 could be seen trees of all growth classes. In sample plots 7, 10 and 11 there are not trees of growth class V and in sample plots 3, 8, 9 and 12 – trees of IV and V class. From the investigation carried out was established that in the upper part of the canopy of beech stands (I and II class) are concentrated 76.5% from the trees, in the middle – 13.2% and in the lower 5.2%. This distribution is normal for the stands in which growing and sanitary cuttings were performed during the process of growth and development. The average diameters of the trees in sample plots are within the frames of 16.7 cm (SP 9) to 50.8 cm (SP 4) and are closely related to their age and stands' condition. According the age classes the change of mean diameter values is from 20.3 cm (III class) to 45.7 cm (VII class).

In table 3 are summarized the most frequent damages on beech stems in the sample plots by altitude and forest type.

In the lower forest vegetation zone – forest type 12. Dolinna gorunovo-bukova dabrava most frequently are the necrosic diseases (28.7%), the insect species *Ectoedemia liebwerdella* Zim. (27,5%), as well as high percentage of mechanical damages caused by silvicultural activities took place leading to wood destroying fungi development. Relatively high is the percentage of frost damages (6.2%) on the stems despite of the more favourable climate conditions.

In the zone up to 1000 m 14. Sveja bukovo-gorunova gora s gabar the necroses reach its maximum (35.7), mechanical damages 14.3% and the frost damages are the most frequent – 7.2%.

Table 3. Beech Stem damages in Sample Plots According to altitude

Altitude, m	Sample plot	Damage type (%)						Forest type (Penev, 1969)
		Nec-roses	Mech. damages	E.lieb-werde-lla	Wood destruction	Frost cleft	A. rugosa	
From 500 m	11, 8	28,7	20,0	27,5	11,2	6,2	3,8	12. Dolinna buk.- gabarova dabrava
Up to 1000m	7, 2, 5, 1	35,7	14,3	2,2	1,0	7,2	1,5	14. Sveja buk.-gorunova gora
Above 1000 m	6, 12, 4, 9, 10, 3	28,8	20,3	14,3	8,5	3,8	13,3	15. Bukova gora s kapina 16. Bukova gora sas swetlika 17. Bukova gora s lazarkinia
Mean value		31,7	18,2	14,7	6,9	5,7	6,2	

In the upper part of the forest types investigated: 15. Bukova gora s kapina, 16. Bukova gora sas svetlica, 17. Bukova gora s lazarkinia the presence of necroses decreased (28.8%), the mechanical damages are relatively high – 20.3%, wood destraing fungi and rotting processes – 8.5%. The insect pest *Ectoedemia liebwerdella* and the fungus *Ascodichaena rugosa* are with significant participation – 13-14%.

The bark necrosis is caused by development of genus *Nectria* fungi (*Nectria galligena* Bres., *Nectria coccinea* Pers.) present in all plots investigated. The species *Nectria cosmariospora Ces et De Not* is found in SP 3. The fungi *Nectria galligena* and *Nectria coccinea* are present more frequently in stands created on typical beech areas on more influenced by atmospheric conditions (SP 9) while in the closed parts at lower altitude (SP 7) they are less. The appearance and development of necroses on the bark create very good conditions for wood destroying fungi to penetrate (*Fomes fomentarius* – SP 1, 8), *Stereum* sp. – SP 3) and this leads to loss and devaluation of the timber.

The mechanical damages are mainly a result of non-following of the instructions of cutting and yarding of the timber. The stem damages in the ground part reach as an area about 20-30%% from the area of DBH and in SP 3 – up to 40% of the bark dies and processes of wood rotting start.

The frost damages are usually result of the temperature differences in the peripheral and central part of the stems in their south and south-west side. They are found in almost all the stands but the damages caused by them are insignificant.

The fungus *Ascodichaena rugosa* causes 'blackness' on the bark in the stem ground part reaching 3 m height. The damages by it are insignificant and only in SP 12 the affected trees are 40% but in the rest of the sample plots its distribution is weak.

During the investigation were found insects-vectors of necrotic diseases. The species *Cryptococcus fagi Barensp.* is closely related to fungi of *Nectria* genus and especially *N. coccinea* which is highly pathogenic. The number is low and till now it does not cause serious danger for the beech.

Ectoedemia liebwerdella Zim is relatively unknown for our beech forest insect. It causes bark breaking and is a vector for fungi spores leading to necrotic diseases. Its distribution is mainly on the south part of the stem and reaches an altitude of 1000 m.

4. CONCLUSION

As a result of the investigation carried out in 5 types beech dendrocoenoses in the vegetation diapason 480 – 1400 m in Middle Balkan Range in the period of climatic anomalies and forced anthropogenic pressure it was established that:

– The stands investigated are with normal structure, height and width growth. Their canopy is formed mainly by dominant trees of I and II growth class (70-80%). In the middle part of III class are 13-15%. Under the main canopy the trees of IV and V class are 3-6% and in some cases they are lost or taken out during the sanitary cuttings done.

– From the damages found on tree stems most frequent are the necrotic diseases caused by the *Nectria* genus fungi (31.7%) and the carrier of the new for our country species *Ectoedemia liebwerdella* Zim. (14.7%).

– Non-following of the technological instructions during the cuttings and taking out of the timber leads to mechanical damages and rotting processes caused by wood destroying fungi *Fomes fomentarius* and *Stereum* sp.

– Until now the pathogenic processes in beech forests of Middle Balkan range flow slowly and there is not drastic change in the structure and health status of the stands.

Knowing the biology of the necrotic diseases as well as the stages of their development allows paying more attention on the management of beech stands.

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THE FOLLOWING OF POPULATIONS' DYNAMICS OF SPECIES *IPS TYPOGRAPHUS* L. AND *PITYOGENES CHALCOGRAPHUS* L. (*COLEOPTERA, SCOLYTIDAE*) AND THEIR PARASITOIDS *RHOPALICUS TUTELA* WALK. AND *ROPTOCERUS XYLOPHAGORUM* RATZ. (*CHALCIDOIDEA, PTEROMALIDAE*) ON COMMON SPRUCE (*PICEA ABIES* L.) IN THE AREA OF PROKLETIJE MOUNTAINS

Dragan ROGANOVIĆ, Vesna JOVOVIĆ[1]

Abstract: *The area of Prokletije mountains, that includes a few tenth of mountain ranges with direction southwest-northeast, represents one of the most interesting, most beautiful and the most unreachable mountain systems of the Balkans peninsula. The plexus of Prokletije mountains is very complexed and various, with tops over 2000 m, very comlexed geomorphology of terrain, different climatic influences, specific geology and pedalogical characteristics, represents one of the most important center of species diversity of Europe. During 1995, 1996 i 1997 years at 10 localities in the area of Prokletije mountains there were performed entomological researches on Common spruce (Picea abies L.). Branches of Common spruce (Picea abies L.), attacked by bark beetles were collected by itinerary method and they were put in insulators because of raising in laboratory conditions. During three years of research, material was colllected in june and than raising adults of bark beetles and their parasitoids were followed until the end of October. An equal amount of branches, that was 0,04 m^3, was collected in insulators. From raised material, populations' dynamics of species of bark beetles Ips typographus Linne 1758 and Pityogenes chalcographus Linne 1758 (Coleoptera, Scolytidae) and their natural enemies, species Rhopalicus tutela Walker, 1836 and species Roptocerus xylofagorum Ratzeburg, 1844 (Chalcidoidea, Pteromalidae) were followed. Species Rhopalicus tutela is parasitoid of the most of species Scolytidae. On the area of Prokletije it has been concluded for the first time by these researches and it was raised from the species Ips typographus (Roganović, 1999). Species Roptocerus xylofagorum is parasite on numerous species of Scolytidae. a*

Key words: Prokletije, Common spruce, bark beetles, parasitoids

1. INTRODUCTION

The area of Prokletije, that covers few dozens of mountain chains which spread in the direction of southwest-northeast, represents one of the most interesting, most beautiful and unreachable mountain systems in the Balkans. Remarkable sceneries, thick deciduous, mixed

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and coniferous woods, wide pasturages, mountain tops, forelands and creases make it the unique area of special importance that is necessary to protect. Concatenate of Prokletije mauntians, very complex and diversified, with mountain tops of over 2000 m, complex geomorphology of the ground, different climate influences, specific geology and pedological characteristics, represents one of the most important centers of the species diversity in Europe.

In the natural ecosystems there is a possibility of grading the insects, but their frequency and amplitude are a lot smaller than in ecosystems that are under the influence of man. The main cause of that are the interactions among the species, predator and parasite insects and diseases (Mihajlović & Ristić, 1994). Factors of the environment, that is the area in which population can be found, that is ecological factors affect all the organisms, and on some organisms their influence is of crucial importance. Anthropogenic and degraded ecosystems often lack of natural enemies or their abundance is changed and therefore the role in the ecosystem of the mentioned organisms is reduced (Mihajlović & Ristić, 1994).

The family of bark beetles (*Scolytidae*) belongs to the group of insects whose population dynamics, besides general ecological conditions, depends before all on conditions of the near ambient which they inhabit (Georgijević, 1962). These conditions concern mostly the nutrition and the suitable environment for the development of certain individuals and its generations, while on the other hand, these conditions depend on climate factors and microclimate relations that exist in the micro ambient in which they are developing (Georgijević, 1962).

In coniferous woods of middle Europe bark beetles occassionaly appear as locust-tree of special economical significance. This primarily concerns the Common spruce *Ips typographus* L that together with the other Common spruce bark beetles, and especially the small *Pityogenes chalcographus* L is constantly endangering and damaging the Central Europe Common spruce forests. One of the biggest calamities in Europe in which the most important part took the *Ips typographus* L, lasted almost 10 years, from 1941 to 1950 (Georgijević, 1962).

Common spruce (*Picea abies* L.), as one of economically most important species of forest trees in Europe, it is permanently endangered from the whole line of bark beetles species, therefore during a long period special attention has been paid to Common spruce, especially from entomological point of view.

During the research on abundance of bark beetles and their parasitoids on the field a numerous irregularities which concern the husbandry of forests, such as large amounts of fallen unbarked trees, high and unbarked logs, remains of irregular and illegal lumbering, not keeping the forest order (trees of all dimensions dispersed on lumbering lots), dents caused by different factors, devastated and sparce forests with phisiologically weakened trees, fire remains etc.

Very little is known about the parasitoide species *Ips typographus* i *Pityogenas chalcographus* in this area, especially about their abundance and possibilities of regulation of total population number, since *Ips typographus* i *Pityogenes chalcographus,* as most important secondary species that attack the Common spruce (*Picea abies* L.), are prone to over numbering.

Researches on parasitoids *Scolytus intricatus* done by Marković, 1999. have shown that average value of the total percentage of parasitism in the examined samples amounted to 14,4%. Researches of parasitoid *Scolytus rugulosus* (Mihajlović et al. 1994, cit. Marković,1999) have pointed at concrete results and possibilities of regulation total population number of species *Scolytidae* by their natural enemies, that is parasitoids, whose average parasitism amounted to 43,7%. The results of research on oaks bark beetles done by Čapek et al., 1987 (cit. Marković, 1999) have shown that parasitism percentage of *Scolytus intricatus* in Slovakia during 1984 and 1985 was between 5% and 46%.

2. MATERIAL AND METHOD

Researches have been done in the period from 1995. to 1997. Material was gathered by itinerary method.

Bark of Common spruce (*Picea abies* L.), which are attacked by the bark beetles, were collected by itinerary method and then put in the isolators for the purpose of cultivation in the laboratory conditions. During three years of research, material was collected in June and July and afterwards the appearance of adults and its parasitoids was monitored until the end of October. Inside the isolators the same amount of collected barks, 0.04 m^3 was put. Determination of bark beetles was done on the base of key Karaman, Z. (1971), while the determination of family specie *Pteromalide* (*Chalcidoidea*) was done by prof. dr Ljubodrag Mihajlović from the Forestry Faculty in Belgrade, to whom we take this opportunity to express our most sincere gratitude.

Localities on which the material was collected:

- Dečanske Mountains 1100 m n.v. DN 41
- Goraždevački Stanovi 1400 m n.v. DN 32
- Dreljski Nedžinat 1600 m n.v. DN 31
- Bojovići 1650 m n.v. DN 32
- Lovski Potok 1400 m n.v. DN 31
- Pleća 1500 m n.v. DN 32
- Alagina reka 1500 m n.v. DN 32
- Jodovo 1500 m n.v. DN 31
- Mokra Gora (Savino Jezero) 1800 m n.v. DN 54
- Miliševac 1200 m n.v. DN32

3. RESULTS

From the sample that was cultivated monitoring was done on population dinamic of the bark beetles specie *Ips typographus* Linnaeus i *Pityogenes chalcographus* Linnaeus (*Coleoptera, Scolytidae*) and their natural enemies *Rhopalicus tutela* Walker, 1836 i *Roptocerus xylofagorum* Ratzeburg, 1844. (*Chalcidoidea*, *Pteromalidae*) (Tables 1. i 2.) that exist as parasitods of the specie *Scolytidae*.

The specie *Rhopalicus tutela* was registered on the area of Prokletije as parasitoid of the specie *Ips typographus* (Roganović, 1999). It is also registered in Serbia as parasitoid of the specie *Scolytus intricatus* (Marković & Stojanović, 1996). The specie *Roptocerus xylophagorum* parasites also on the larger number of *Scolytidae* species (Bouček, 1977). During our researches it was produced by cultivation from species *Pityogenes chalcographus, Pityophthorus lichtensteini* and *Pityocteines curvidens*. The species *Roptocerus xylophagorum* was registered in the area of Prokletije (Roganović, 1999)

4. DISCUSSION

Three year researches about the total number of specie *Ips typographus* L. (*Coleoptera, Scolytidae*) and its parasitoid *Rhopalicus tutela* Walk. (*Chalcidoidea, Pteromalidae*) and specie *Pityogenes chalcographus* L. (*Coleoptera, Scolytidae*) and its parasitoid *Roptocerus xylofagorum* (*Chalcidoidea, Pteromalidae*) cultivated from the samples collected on 10 localities in the area of Prokletije showed the following:

The largest percentage of parasitism *Ips typographus* from *Rhopalicus tutela* (table no. 1) was registered on the sample which was collected on the locality Miliševac on 21.07.1997 and that

Table 1. Monitoring of the total nuber of adults Ips typographus and parasitoid Rhopalicus tutela in the laboratory conditions on the material collected in the Prokletije Mountains

Localities	Date of collection	Σ IT	N RT	Parasitism %
Dečanske Mountains	22.06.1995 26.06.1996 20.06.1997	164 105 115	11 5 9	6.28 4.55 7.26
Total: Dečanske Mountains		384	25	6.11
Goraždevački stanovi	23.07.1995 17.07.1996 20.7.1997	52 63 39	31 39 58	37.35 38.23 59.79
Total: Goraždevački stanovi		154	128	45.39
Dreljski Nedžinat	17.07.1995 15.07.1996 20.07.1997	151 147 114	8 8 22	5.03 5.16 16.18
Total: Dreljski Nedžinat		412	38	8.44
Bojovići	15.07.1995 10.07.1996 17.07.1997	35 75 23	11 14 9	23.91 15.73 28.12
Total: Bojovići		133	34	20.36
Lovski Potok	10.07.1995 15.07.1996 22.07.1997	86 92 104	32 20 25	27.12 17.86 19.38
Total: Lovski Potok		282	77	21.45
Pleća	15.07.1995 10.07.1996 18.07.1997	13 21 15	25 25 38	65.79 54.35 71.70
Total: Pleća		49	88	64.23
Alagina Reka	15.07.1995 10.07.1996 07.07.1997	70 47 35	11 15 9	13.58 24.19 20.45
Total: Alagina Reka		152	35	18.72
Jodovo	21.06.1995 15.06.1996 20.06.1997	18 18 12	0 0 0	0 0 0
Total: Jodovo		48	0	0
Mokra Gora (Savino Jezero)	20.07.1995 22.07.1996 24.07.1997	45 42 7	18 24 46	28.57 36.36 86.79
Total: Mokra Gora (Savino Jezero)		94	88	48.35
Miliševac	15.07.1995 18.07.1996 21.07.1997	20 7 2	18 22 30	47.37 75.86 93.75
Total: Miliševac		29	70	70.71
TOTAL		1737	583	25.13

Σ IT – total number of appeared adults *Ips typographus*; N RT– total number of appeared adults of parazitoide *Rhopalicus tutela*; P – parasitism (%)

Table 2. Monitoring of total number of adults Pityogenes chalcographus and parasitoid Roptocerus xylophagorum in the laboratory conditions on the sample collected on the Mountains Prokletije

Localities	Date of collection	S PC	N RX	Parasitism %
Dečanske Mountains	22.06.1995 26.06.1996 20.06.1997	126 76 90	4 4 2	3.08 5.00 2.17
Total: Dečanske Mountains		292	10	3.31
Goraždevački stanovi	23.07.1995 17.07.1996 20.7.1997	86 86 65	10 9 2	10.42 9.47 2.98
Total: Goraždevački stanovi		237	21	8.14
Dreljski Nedžinat	17.07.1995 15.07.1996 20.07.1997	99 102 102	0 1 5	0 0.97 4.67
Total: Dreljski Nedžinat		303	6	1.94
Bojovići	15.07.1995 10.07.1996 17.07.1997	40 64 18	4 2 0	9.09 3.03 0
Total: Bojovići		122	6	4.69
Lovski Potok	10.07.1995 15.07.1996 22.07.1997	67 47 67	10 6 8	12.99 11.32 10.67
Total: Lovski Potok		181	24	11.71
Pleća	15.07.1995 10.07.1996 18.07.1997	9 13 8	14 24 16	60.87 64.86 66.67
Total: Pleća		30	54	64.29
Alagina Reka	15.07.1995 10.07.1996 07.07.1997	54 15 27	4 1 3	6.90 6.25 10.00
Total Alagina: Reka		96	8	7.69
Jodovo	21.06.1995 15.06.1996 20.06.1997	16 13 7	0 0 0	0 0 0
Total: Jodovo		36	0	0
Mokra Gora (Savino Jezero)	20.07.1995 22.07.1996 24.07.1997	39 71 15	8 5 34	17.02 6.58 69.39
Total: Mokra Gora (Savino Jezero)		125	47	27.32
Miliševac	15.07.1995 18.07.1996 21.07.1997	39 11 12	8 11 22	17.02 50.00 64.71
Total: Miliševac		62	41	39.81
TOTAL		1484	217	12.76

Σ PC – total numer appeared adults *Pityogenes chalcographus*; N R X – total number appeared adults of parasitoide *Roptocerus xylophagorum*; P – parasitism (%)

percentage was 93,75%. The smallest percentage of parasitism *Ips typographus* from *Rhopalicus tutela* was registered on the sample collected on the locality Dečanske planine on 26.06.1996 and it amounted to 4,55%. On the locality Jodovo there were no records of parasitism *I. typographus* from *R. tutela* during the research period.

The largest average value of the total parasitism percentage of *I. typographus* from *R. tutela* during the three year cultivation period was registered from the samples that were collected on the locality Miliševac and it was 70,71%.

The smallest average value of the total parasitism percentage of *I. typographus* from *R. tutela* during the three year period was registered from the samples that were collected on the locality Dečanske Planine and it was 6,11%.

Average value of the total parasitism percentage of *I. typographus* from *R. tutela* on the samples from all localities during the research period was 25,13%.

The largest percentage of parasitism *Pityogenes chalcographus* from *Roptocerus xylophagorum* (table no. 2) was recorded on the sample that was collected on the locality Mokra Gora (Savino jezero) on 24.07.1997 and it was 69,39%. The smallest percentage of parasitism *Pityogenes chalcographus* from *Roptocerus xylophagorum* was recorded on the sample that was gathered on the locality Dreljski Nedžinat on 15.07.1996 and it was 0,97%. On the locality Jodovo there were no records on parasitism of *P. chalcographus* from *R. xylophagorum* during the research period.

The largest average value of the total parasitism percentage of *P. chalcographus* from *R. xylophagorum* during the three year cultivation period was registered from the samples that were collected on the locality Pleća and it was 64,29%.

The smallest average value of the total parasitism percentage of *P. chalcographus* from *R. xylophagorum* during the three year period was registered from the samples that were collected on the locality Dreljski Nedžinat and it was 1,94%.

Average value of the total parasitism percentage of *P. chalcographus* from *R. xylophagorum* on the samples from all localities during the research period was12,76%.

5. CONCLUSION

Average value of the total parasitism percentage of *Ips. typographus* from *Rhopalicus tutela* was 25,13% and average value of the total parasitism percentage of *Pityogenes chalcographus* from *Roptocerus xylophagorum* was12,76%.

The specie *Rhopalicus tutela,* besides being a parasite to the species of family *Scolytidae,* is trophic linked also to the species *Pissodes* (Bouček, 1977) and specie *Roptocerus xylophagorum*, besides on *P. Chalcographus,* was registered as parasitoid of species *Pityophthorus lichtensteini* Ratz. i *Pityocteines curvidens* Germ. (Roganović, 1999)

Taking into account the mentioned data, certain amount of cautiousness and reserve is always necessary when it comes to importance and role of parasitoids *R. tutela* and *R. Xylofagorum* in the reduction of number of species *I. typographus* i *P. chalcographus* as species that are prone to gradations.

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INTERACTION OF THE FUNGUS *LENTINUS EDODES (BERK.) SING.* AND SOME PIONEER SPECIES OF OAKWOOD DECAYING FUNGI IN THE SAME NUTRITIVE MEDIUM *IN VITRO*

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Abstract: *The competition for food and space is the basic and the most frequent type of competition among living organisms. In the case of wood-decaying fungi which colonise the same nutritive medium, namely the same wood species, the question of succession and the order of wood colonisation by certain fungi, inter alia, depends greatly on the competitive ability of certain species to oppose the inhibiting substances exuded by the opponent fungus. These relations in nature are very complicated because, at the same time, the medium is attacked by numerous microorganisms, requesting different optimal conditions for their growth and affecting the colonised medium in different ways. In nature, it is almost impossible to observe all these relations, so the investigations are mainly performed in vitro, by using the so-called mixed cultures. Due to the necessary simplification of the conditions during the investigation, compared to those occurring in nature, the study results should be taken just as an orientation and a possible indicator of the phenomena occurring in nature. The interaction of the fungus Lentinus edodes (Berk.) Sing. was tested in relation to some pioneer species of wood-decaying fungi colonising oakwood in the same conditions. The tests were performed with some steroid species of fungi occurring very often and almost always present in the stands and storages. The investigations were undertaken in mixed cultures and the interaction of fungi was defined during the approaching of the growing mycelial fronts of the competing fungi. The indexes of sensitivity of individual species in the mixed cultures, as well as the reaction types of the pairs of antagonistic fungi, were determined. The appearance of inhibition zone, slowing of growth, stimulation of growth or collapse of hyphae was observed. The results show that L. edodes always formed an inhibition zone and stopped growing before the contact with the opposite species, although in some cases the growth was slowed down and sometimes, at the beginning, even stimulated. This shows a significant antagonism with the tested steroid fungi and represents the limiting factor for the dominant physiological activities and for the development in the same medium. In practice, this phenomenon could be significant from the aspect of the success of inoculation of thinner oak roundwood or branches by the fungus L. edodes in the aim of producing of fruiting bodies for food or pharmacy.*

Key words: *Lentinus edodes*, shii take, *Stereum hirsutum, Chondrostereum purpureum, Xylobolus frustulatus,* steroid fungi, mixed cultures, growth, antagonism, competition

1. INTRODUCTION

All lignicolous fungi in the field are adapted to the development on the specific nutritive medium. They colonise different species or zones of wood, treating them as the sources of nutritive substances (Cartwrigt, Findlay, 1946). Different fungi have different demands, not only

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regarding the medium, but also regarding all other ecological factors which affect their growth, such as moisture, temperature, pH, light, relative air humidity, etc. (Fries, 1961).

Regardless of their occurring in connection or in succession, several fungi on the same nutritive medium interact, mostly in different forms and often in a very complicated way (Rayner, 1978). Each fungus in such competitive relations can be more or less sensitive to the other antagonistic fungus. The consequences can be antagonism, growth inhibition, growth stimulation, unobstructed growth, till the contact of the mycelial fronts, etc. In the field, there are a great number of different forms and intensities of sensitivity, depending on numerous influential factors.

The attack of several different species of fungi on wood as a common microsite in the field results in the so-called "mosaic rot", which is actually white rot with dark zones which separate the zones of wood colonised by different fungi. The zones colonised by different fungi are readily discernible by their colour. Dark streaks which form mosaic pattern on wood actually present the inhibition zones between two different fungi within wood as the medium (Rayner, 1976).

The dark zones are usually not colonised by fungi, thanks to the high concentration of exudates of the colonised fungi (antibiotics, myco-toxins, etc.) originating from the zone of the front of the growing mycelium. This 3D dark network usually presents whatever remains after the complete wood decomposition. The competition and inter-species relations in the field is almost impossible to monitor. For this reason, numerous methods have been developed in the controlled laboratory conditions, with a prescribed procedure on an artificial nutritive medium. The tests are mainly performed in the so-called mixed cultures, mostly with two antagonistic fungi. This is complicated by many details, so the research methods are characterised by some shortcomings.

During the initial growth on nutritive medium, fungi, before the growing mycelium front, exude some exudates which, in addition to potential growth inhibition or stimulation of the antagonistic culture, also change the concentration of hydrogen ions. In this way, they make the infection and growth easier or more difficult to other fungi on the same medium (Rayner, A. D. M., Boddy, L. 1998).

The issue of connection and succession of species on wood is significant not only from the theoretical aspect and the study of physiological characteristics of the fungi and their bioecological characteristics, but also from the practical significance, aiming at the analysis of the conditions, course and consequences of wood colonisation by lignicolous fungi (Rypaček, V. 1966). Especially significant are the species that colonise our economically most significant tree species, among them, by all means, oak. Although the fungus *Lentinus edodes* in its primary range is adapted to other tree species, in our climate it can be a significant oakwood decay fungus, all the more because oak is an excellent medium for the production of fruiting bodies of this medicinal and edible mushroom. The possibility of spontaneous infection of oakwood by this species on the storages is very significant for practice, as it is a wood destroying fungus. Its interactions with other wood rotting fungi and its competition with other fungi colonising oakwood is by all means of high significance for the success of infection.

In this sense, the research of interactions of some pioneer fungus species with *Lentinus edodes* on oak is significant for the elucidation of the conditions of fungal infection and growth and for the study of its role in oakwood decomposition in nature. For this reason, some steroid fungi were selected, known as facultative parasites, but which can in further course of development and the change of host-plant wood status and vitality, or the nutritive medium, switch to saprophyte method of feeding. So, they are the species which are wood rotting fungi, but which realise their destructive capacity also on physiologically weakened trees, not only on dead wood.

As these fungi readily colonise oakwood in forests and on temporary landings, where *Lentinus edodes* also occurs, they represent the adequate competitors and can be used for the determination of the competitive capacity of *Lentinus edodes* on the same nutritive medium. On the other hand, in the stands during the vegetation period, there is almost always a great number of vital fruiting bodies of these fungi, which are probably most often encountered in the field, and therefore also a very high level of inoculum of these species.

2. MATERIAL AND METHOD

The interactions of *Lentinus edodes* and steroid fungi which colonise oakwood were tested in laboratory conditions by the method of "mixed cultures". The sensitivity index of the tested fungi was determined in mixed cultures, i.e. the types of interaction during the simultaneous colonising (connection) of the same (artificial) nutritive medium. The following species of steroid fungi were researched: *Stereum hirsutum* (Wild. ex Fr.) S. F. Gray, *Chondrostereum purpureum* (Pers. ex Fr.) Pouz. and *Xylobolus frustulatus* (Pers. ex Fr.) Karst.

The species *Stereum hirsutum* causes white rot of oak sapwood and it is one of the most frequent fungi on temporary and industrial storages, and in forests it is most frequent on felled wood (Schmidt, O. 1994). After oak felling, it is one of the first species colonising the wood. The species *Chondrostereum purpureum* is known as the weakness parasite, but also as wood-decay fungus on about 150 tree species, and in orchards it causes silver leaf disease, but during the further course of the disease, it causes white rot of wood (Beever, D. J. 1969).

The fungus *Xylobolus frustulatus* is the only one among these species which colonises oak heartwood and causes alveolar type of decay. It is tolerant to a higher concentration of tannin in heartwood, and the lower concentration of tannins can even stimulate its growth. On the other hand, it can tolerate oxygen deficit which occurs in that zone, while other species of wood-rotting fungi, which are mostly aerobic microorganisms, cannot develop without oxygen or with low oxygen. All three fungi are pioneer species on oak, they are present very frequently and they are significant decay agents.

The cultures of all tested fungi were developed on a solid medium of standard composition (2% malt, 2% agar) in plastic Petri dishes (D = 90 mm) at the temperature of 21 +/- 1°C and relative humidity 70+/- 5%. From such cultures, the inocula of circular form (D = 7 mm) were taken from the mycelial developing zone, and they were used for the formation of mixed cultures.

Each of the tested steroid fungi was combined with the fungus *Lentinus edodes* in a mixed culture.

The inocula of two selected fungi for each combination were plated along the edges of a Petri dish, one opposite the other. Three replications were used for each tested combination. The slower-growing species *Xylobolus frustulatus* was inoculated 3 - 4 days before *Lentinus edodes*, to prevent the overgrowing of the entire medium by the superior species, i.e. only after the beginning of the development of the slower-growing species had been observed.

All the cultures were incubated in the climate-chamber in standard conditions, and for *X. frustulatus* an additional series was established at the temperature of 28°C, as this is the optimal temperature for the development of this fungus and standard conditions can practically present the wrong image regarding its susceptibility to other tested phenomena.

The mycelial growth was marked every 24, i.e. 48 hours, depending on the rate (i.e. slowing) of growth of individual fungi in mixed cultures.

The growth of both fungi (in the same Petri dish) was measured (in mm) in three directions, in the direction of the dish radius and to the left and right at the angles of 22.5° to the diameter. Based on the growth measurement in three directions, in three replications, the growth of fungi was determined separately for each day and the values were graphically presented (by the method proposed by Ekstein, D. and Liese, W. 1968) and analysed.

Parallel with the incubated mixed cultures, under the same conditions, the growth of the so-called single cultures was monitored on the standard nutritive medium, which represented the control. The inocula were, like in the mixed culture (but in this case individually) plated along the edge of Petri dishes and the growth was marked simultaneously with the mixed culture.

The results, i.e. the values showing the growth of fungi for each day from the beginning measurement are graphically presented by growth curves in one Diagram for each fungus from the mixed culture, as well as for each fungus from single-culture (control). So, each Diagram consists of 4 growth curves. The Diagram is formed of two coordinate systems, abscissas at 180^{O} and with the distance which (for each Diagram) corresponds to the exact spacing between inocula, i.e. the first marked line of fungal growth in mixed cultures.

The base coordinate system presents the growth curves of steroid fungi in single and mixed cultures, and the opposite system presents the growth curves of *Lentinus edodes*, also in single and mixed cultures.

Based on the study results of growth rate in single and mixed cultures, the indexes of sensitivity of individual fungi were defined, as well as the reaction types which occurred in mixed cultures.

By the analysis of the above indicators, the interaction of two fungi in the controlled conditions on the same nutritive medium was precisely determined by the modified method proposed by Ekstein, D. and Liese, W. (1968). To determine the interaction of fungus species (in mixed culture), 9 indexes of sensitivity (Is) were defined, which characterise the mycelial growth rate (unobstructed, slowed down or stimulated) compared to the control (the same species in single culture), as well as the behaviour of the mycelia during the approaching, and at the contact of the fronts of mycelia of antagonistic fungi (stopping before or at contact, overgrowth, undergrowth, or hyphal collapse).

To analyse the interaction of two antagonistic fungi in a mixed culture, 3 reaction types (Rt) were defined, based on the indexes of sensitivity of individual species in the defined combinations, which integrally determine the effect, i.e. the interaction of the species in mixed cultures.

The characteristics of individual indexes of sensitivity (Is) are defined as:

0 - Unobstructed growth and stopping before contact with the other fungus;

1 - Slowed growth before contact and complete stopping at contact;

2 - Slowed growth before contact and growth over the other mycelium after contact;

3 - Unobstructed growth before contact and stopping at contact;

4 - Unobstructed growth before contact and growth over the other mycelium after contact;

5 - Stimulated growth before contact and stopping at contact;

6 - Stimulated growth before contact and growth over the other mycelium after contact;

7 - Slowed down growth and stopping before contact;

8 – Stimulated growth and stopping before contact;

The characteristic reaction types (Rt) observed in this research are reflected as follows:

I - Both fungi slow down before contact, and at contact one stops while the other overgrows;

II - One fungus has unobstructed growth, the other has stimulated growth but they both stop before contact;

III - One fungus has stimulated growth, the other slows down, but both stop before contact;

IV - One fungus has stimulated growth and stops before or at contact, while the other slows down, but after contact overgrows the first one.

Based on the character of the presented sensitivity reactions, it can be concluded that the fungi in mixed cultures had an antagonistic effect on the species with sensitivity indexes 0, 7, and 8 (growth stopping before contact); inhibitory effect - on species with sensitivity indexes 1, 2, 3, and 5 (slowed down growth); stimulative effect – on species with sensitivity index 6 (stimulated growth) and indifferent effect - to species with sensitivity index 4 (unobstructed growth).

3. RESULTS AND DISCUSSION

The Tables of sensitivity indexes (Is) and reaction types (Rt) were made based on the analysis of the Diagrams for each tested combination of fungi in mixed cultures (Tables 1 and 2).

Table 1: Sensitivity indexes (Is) of Lentinus edodes and tested steroid fungi in mixed cultures on malt-agar medium

Fungus	Stereum hirsutum		Chondrostereum purpureum		Xylobolus frustulatus			
	21°C		21°C		21°C		28°C	
L. edodes	5	2	2	1 *	0	8	8	7

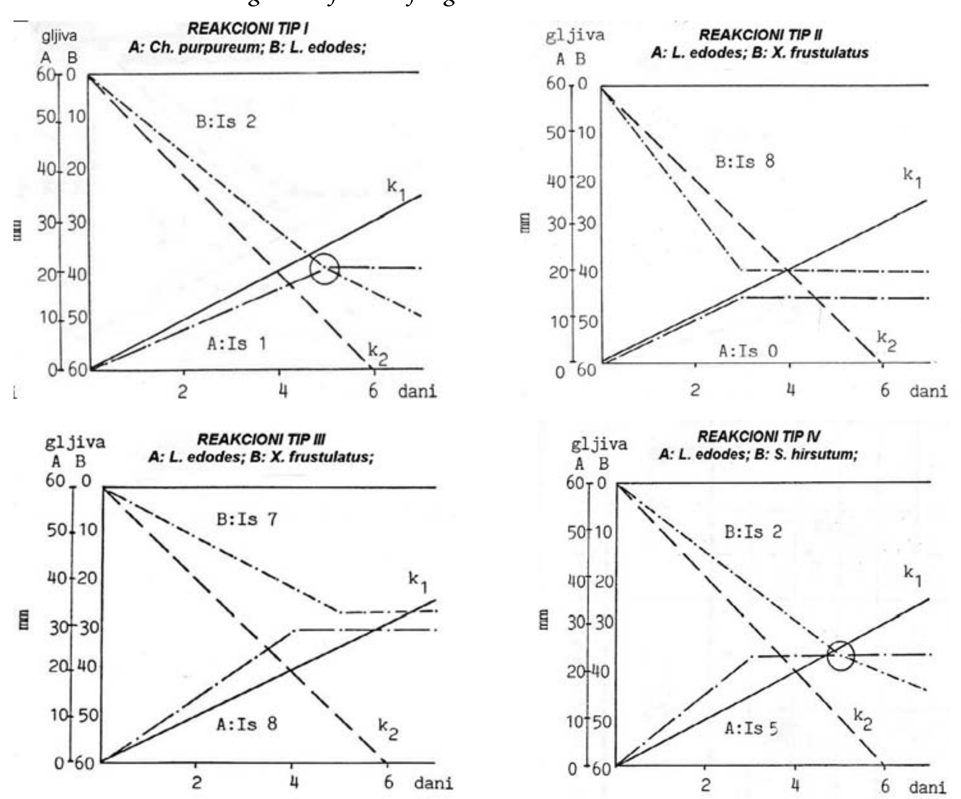
*collapse of hyphae

Table 2: Reaction types (Rt) of Lentinus edodes and tested steroid fungi in mixed cultures on malt-agar medium

Fungus	Stereum hirsutum	Chondrostereum purpureum	Xylobolus frustulatus	
	21°C	21°C	21°C	28°C
Lentinus edodes	IV	I *	II	III

* collapse of hyphae

Diagrams of tested fungi interaction in mixed cultures



***k_1** and **k_2**: Growth lines of tested fungi in single cultures (control);*
***A** and **B**: Growth lines of tested fungi in mixed cultures (test);*

Based on the observed growth rate of fungi in mixed and single cultures, it was concluded as follows:

In mixed cultures, *L. edodes* mycelium had stimulated growth till the contact with *S. hirsutum* which, although inhibited in growth, after contact grew (Is 2) over the contact line with *L. edodes* (Is 5) (Rt IV).

Species *L. edodes* inhibited the growth of the fungus *Ch. purpureum* (Is 1) and overgrew it after contact (Is 2), which resulted in the collapse of *Ch. purpureum* hyphae in the zone of contact of mycelial fronts (Rt I).

The analysis of the study results of *L. edodes* and *X. frustulatus* interaction in mixed cultures at standard temperature of 21°C shows that both fungi stop growing before the contact of mycelium fronts, showing the antagonistic interaction and creating a wider or narrower inhibition zone, but during the approaching of mycelium fronts, *L. edodes* had an unobstructed growth (Is 0), and *X. frustulatus* had a stimulated growth (Is 8; Rt II).

It could be stated that an increased temperature (28°C) had an unexpected effect and on both species in mixed culture. Namely, *L. edodes* was stimulated during the approaching of mycelium fronts, although its optimal growth temperature is about 22°C (Is 8), while *X. frustulatus* was slowed down (Is 7), although this temperature was optimal for its growth. Both mycelia stopped growing completely before contact and formed a distinct inhibition zone (Rt III).

Based on these results, it can be concluded that the temperature of 28°C, which is otherwise favourable to the development of *X. frustulatus* mycelium in pure culture, has no decisive effect in mixed cultures for this species in the sense of growth stimulation. On the other hand, because of the shown effect of higher temperature on mycelium growth and on the reaction of antagonistic fungus *L. edodes,* it can be concluded that the favourable effect which should result from increased temperature to the optimal level (of 28°C) is considerably reduced or completely annulled for *X. frustulatus* in mixed cultures. Such interactions of factors and their effect on life processes or relations in the sense of stimulative, inhibitory or antagonistic effects are known and always present in nature.

The presented study results of *Lentinus edodes* interaction with the selected steroid fungi should be observed in the light of the fact that, in natural conditions, steroid fungi, as opposed to the majority of *Basidiomycete* species, which can colonise wood previously colonised by other microorganisms, require fresh wounds for infection and penetration in wood (Etheridge, 1973 - after Frankland). Based on the *in vitro* results with *L. edodes*, it could be supposed that this species has a competitive capacity sufficient for spontaneous infection of oakwood in natural conditions, in case of the favourable ecological conditions, at least in cases of the tested steroid fungi.

According to some authors, in laboratory tests on oak discs, some wood rotting fungi, among which *Ch. Purpureum,* dominated over some lignicolous fungi (e.g. *Gliocladium roseum*, *Paecilomyces sp.* and *Trichoderma viride*) from the previous collective group *Fungi Imperfecti* (*Deuteromycotina*) in competing on a nutritive medium. It was the opposite case on an artificial nutritive medium (glucose / yeast extract /agar) (True, R.P., Mac Donald, W.L., 1973), which indicates that the natural composition of the medium can have a decisive significance for the interaction of fungi on the same medium. The results reported by Rayner, A.D.M. (1978), however, show that the interactions in 251 tested combinations (9 with 26) of fungi colonising *Quercus robur* logs, were similar on artificial malt - agar medium and inside wood, till 29 months after inoculation. Also, there were occurrences of growth inhibition or intra-species antagonism (somatic incompatibility) between individual mycelia of the same fungal species growing in *Q. robur* wood.

Aiming at a more complex study of connection and succession, as well as interaction of fungi on wood as the medium, in the following research attention should be focused to the effect of the different composition of nutritive medium, tannin concentration, temperature, as well as the moment of inoculation of antagonistic fungi in mixed cultures, on the growth and behaviour, i.e. the degree of antagonism or antibiotic effects among the tested fungi. The results of such research should present the clearer guidelines for the continuation of the more concrete research on wood as a living or dead nutritive medium. The competitiveness of microorganisms in the last thirty years has been used for the biological control of fungi which cause diseases and wood decay (Rishbeth, J., 1963). The best known example is the application of fungus *Peniophora gigantea* in the suppression of the attack of the species *Heterobasidion annosum,* which is the worldwide problem number one in forestry, infesting great forest complexes and destroying an enormous quantity of wood (Rishbeth J., 1963), or bacterium *Pseudomonas hickorii* against fungus *Ceratocystis fagacearum* (agent of vascular tissue diseases), which causes mass dying of oak in USA (Feiler, 1990 - pers.com.).

4. CONCLUSION

Based on the study results of the growth rate of the fungi in mixed and single cultures, it was concluded that *L. edodes* mycelium was stimulated in growth, but only till the contact with *S. hirsutum* which, although inhibited during the approach, grew over the contact line after the contact with *L. edodes*.

Species *L. edodes* inhibited the growth of *Ch. purpureum* and it overgrew it after the contact, which caused the collapse of *Ch. purpureum* hyphae in the contact zone of mycelial fronts.

The analysis of study results of *L. edodes* interaction with *X. frustulatus* in mixed cultures at the temperature of 21°C shows that both fungi stopped growing before the contact of mycelial fronts, showing the antagonistic interaction and creating a wider or narrower inhibition zone, but during the approaching of mycelium fronts, *L. edodes* had an unobstructed growth, and *X. frustulatus* had a stimulated growth.

An increased temperature (28°C) had an unexpected effect on both species in mixed culture. Namely, *L. edodes* was stimulated during the approaching of mycelium fronts, although its optimal growth temperature was about 22°C, while *X. frustulatus* was slowed down, although this temperature was optimal for its growth. Both mycelia stopped growing completely before the contact and formed a distinct inhibition zone, as it was the case at the temperature of 21°C. Based on these results, it can be concluded that the temperature of 28°C, which is otherwise favourable to the development of *X. frustulatus* mycelium in pure culture, has no decisive effect in mixed cultures for this species from the aspect of growth stimulation. On the other hand, because of the shown effect of higher temperature on mycelium growth and on the reaction of the antagonistic fungus *L. edodes,* it can be concluded that, for this species, a somewhat higher temperature is more favourable in mixed culture. Such interactions of factors and their effect on physiological processes or interactions in the sense of stimulative, inhibitory or antagonistic effects are known and always present in nature.

Based on the *in vitro* results with *L. edodes*, it could be supposed that this species has a competitive capacity sufficient for the spontaneous infection of oakwood in natural conditions, in case of the favourable ecological conditions, and in competition with *Chondrostereum purpureum*. Fungus *L. edodes* in competition with *Stereum hirsutum* and *Xylobolus frustulatus* in laboratory conditions (*in vitro*) shows an antagonistic effect, so the success of colonising the medium in natural conditions (*in vivo*) in the competition with these species probably lies in the favourable ecological conditions for individual species, as well as in the priority of colonising and developing its mycelium in wood.

Aiming at the more complex study of the species connection and succession, as well as their interaction on wood as the medium, this method should be applied in the research of a greater number of fungi which colonise oak wood.

In the following research, attention should be drawn to the research of the effect of different composition of nutritive medium, tannin concentration, temperature, as well as the moment of inoculation of antagonistic fungi in mixed cultures, on growth and behaviour, i.e. the degree of antagonism or effects in general. The results of such research should present the clearer guidelines for the continuation of the more concrete research on wood as a living or dead nutritive medium and it should make easier the establishment of methodologically correct experiments *in vivo*.

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BURR FORM OF BLACK POPLAR (*POPULUS NIGRA* L.) IN BULGARIA

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Abstract: *After the introduction of Populus deltoides Marsh. in Europe fast process of natural hybridization with the European black poplar took place. As result the indigenous poplar almost disappear as pure, from genetic point of view, species from our continent. In Bulgaria solitary trees of Populus nigra still are preserved along the river beds of Danube and the inner rivers. One of the most interesting and valuable forms is the burr form with "curly-grained" wood, which in the present work we consider as form of survival and adaptation to the aggravated site conditions. Characteristic for these trees is the formation of swellings consisting of colonies of dormant buds. The wood of these swellings is highly decorative and used in craft production. The specific characteristics of this form, as well as the still ongoing process of general decline of black poplar as taxonomic unit, impose urgent measures for conservation and propagation of its valuable varieties.*

Key words: *Populus nigra* L., *Populus deltoides* Marsh., curly-grained wood form, propagation, conservation

1. INTRODUCTION

Burr forms are considered by the most scientists as formations of special category resulted by continuously increasing number of dormant buds colonies. The sizes of the burrs strongly vary in diameter and weight – from several centimeters up to 1m and from tens of grams up to more then 1 tone. Their shape can be symmetrical or asymmetrical, oval, spindle-like (Dobrinov et al., 1970; Naidenov, 1979; Sokolov, 1965; Yablokov, 1962).

For the first time in Bulgaria burr form of black poplar (*Populus nigra* L.) was decribed by Dobrinov and Naidenov in 1970.

The mechanism of bur formation is not completely studied yet. According to Dobrinov, Naidenov (1970), Naidenov (1979), Niko pop Nikola (1965), Sokolov (1965), Sukachev (1938), Yablokov (1962) the formation of dormant buds colonies is genetically determined and plays an important role in plant's life. Contrary, Atanasov (1967, 1974), Vanin (1955), Saks & Vakder (1975) etc. consider burr swellings to be a result of reaction towards infections, but not inheriting characteristics.

In this work we support the scientists who accept the burr formation as genetically determined norm of reaction of some black poplar, and other species, individuals towards the aggravated ecological conditions.

The main goal of our investigation is to establish the distribution and extent of participation of burr form in black poplar stands, groups and solitary trees in Bulgaria.

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2. OBJECTS AND METHODS

Objects of the present survey were preserved natural stands and groups of black poplar along the banks of Danube River and the valleys of some inner rivers - Ogosta, Iskar, Vit, Yantra and Osam in northern Bulgaria and Tundja, Mesta, Struma and Topolnitsa in southern part of the country. The investigations were carried out in the period 1972-2005. To study the possibility of burr formation to be inherited characteristics, in the period 1974-1978 cuttings and seeds from individuals with highly expressed ability to form swellings were collected. They were planted, respectively sowed, on the territory of Experimental Station for Fast-growing Species – Svishtov. Stem analysis of 20 trees with swellings at different stages of development was performed in order to examine the process of burr formation. Samples for determination of wood physical-and-mechanical properties and performance of anatomical analysis were taken. Parallel with the other investigations, analysis on the health status of black poplar stands, groups and solitary trees was prepared.

3. RESULTS AND DISCUSSION

The investigations carried out in the period 1972-2005 showed that black poplar trees able to form burr swellings present 30-70% of the still preserved stands, groups and solitary individuals of this species. This process is best expressed in conditions of aggravated environment – strongly drained sites of the Fore-mountain Plains and the places under permanent spring flooding along the Danube river banks. Well preserved solitary trees of *Populus nigra* of strongly expressed burr form were established in Iskar and Kresna Gorges and along the river valleys of Ogosta, Osam, Vit, Yantra, Struma, Mesta, etc. This confirms the hypothesis that the burr formation process in black poplar could be assumed as norm of reaction, way to overcome unfavorable growing conditions. Probably in the process of its evolutionary development this species, as some other broadleaved species, elaborated the mechanism of burr formation in response to repeatedly occurring mechanical and other types of damages, which proves its high ecological plasticity. This is proved also by the fact that intensive pruning of black poplar, linden, and other broadleaved tree species, as demonstrated by the investigations of Yuriev (1963), leads to activate development of adventitious buds and formation of significant in sizes swellings.

It was established, by experimental vegetative propagation of the burr form of black poplar that the percentage of rooted mature cuttings varies in the range of 45-80%. At the end of the fourth year the clones started to form swellings that continuously increase in size. This phenomenon was also observed for cut down burr trees regenerating by sprouts.

The stem analysis performed, showed that dormant buds are formed in the first 3-4 years of the plants' life. Some of them grow up and branch in the next 30-40 years often giving up to 20-30 secondary buds, which cause curving of the wood fibers and appearance of unique ornaments, highly appreciate for the production of craft masterpieces. Along the river valleys of Danube and Tundja trees with burrs up to 1.6 m diameter and 4-5 m height were found.

The exact reason for the formation of dormant buds and their colonies is still not determined. It was proved that the auxins plays an important role in the formation of swellings, burrs inclusive. According the investigations of Alexandrov (1963) the continuous influence with indolyl-3-butiric acid on plant tissues causes active formation of dormant buds. The chromatographic analysis (Naidenov, 1970) proved increased contents of indolyl-3-butiric acid in the tissues of poplar and birch burr forming trees. Probably these species have elaborated in their phylogenetic development the ability to synthesize bigger quantity of auxins under the pressure of certain irritating factors, which determined the formation of more dormant buds as immunity reaction. The trees form callus tissue on the injured places in order to make a protective cover. The callus structure is identical for all plants, but the ability to form it is different and genetically determined.

The results by the stem analysis indicated that, in most of the cases, the growth in height and diameter of burr forming poplars is not disturbed. The existence of trees at ages of about 100 years, and even older, along the valleys of the inner rivers in northern and southern Bulgaria proves that the swellings are caused not by infectious disease but appear as a reaction of the tree immune system towards the environmental changes.

Concerning the anatomic structure of curly-grained wood strongly expressed hyperplasia, due to the activity of dormant buds, is observed. No morphological or anatomical differences in the leaf structure of normal and burr forming black poplar trees was established.

The density of curly-grained wood, examined by physical-and-mechanical methods, is 504 kg/m^3, while that of normal trees is 450 kg/m^3. The pressure in wood fibers direction for curly-grained and normal wood is 20.3 mm/m^2 and 30.0 mm/m^2 respectively, while the flexural strength is 46.9 mm/m^2 and 50 mm/m^2 respectively (Dobrinov, Naidenov, 1970; Kalinkov,1969; Maier, 1931; Stoyanov, Enchev, 1964, Naidenov, 1988).

The curly-grained wood is easily processed and polished, which additionally expresses its decorative texture. It is highly appreciate in furniture production and as craftsmanship material.

4. CONCLUSIONS

Based on the above mentioned results the following conclusions and recommendations can be pointed out:

- The burr form of black poplar is widely distributed in the still preserved stands, groups and solitary trees of this species;
- This form can be accepted as protective adaptation of black poplar towards the aggravating environmental conditions and is inherited in the progeny;
- The ecological plasticity and highly decorative wood texture of this form determine its extreme economic value as genetic resource and source of qualitative material for furniture and craftsmanship production;
- The existing real danger, due to ignorance, still preserved burr individuals of black poplar to be destroyed imposes application of urgent measures for their protection.

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IMPACT OF TEMPERATURE AND CONCENTRATION OF H-IONS ON THE GROWTH AND PRODUCTION OF MYCELIAL MASS OF THE FUNGUS *LENTINUS EDODES (BERK.) SING.*

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Abstract: *The impact of temperature and concentration of H-ions on the growth of fungus Lentinus edodes (Berk.) Sing. was investigated in vitro. These factors, besides the status of nutrients in the medium, inoculum level and virulence, which undoubtedly have to be treated as necessary in the process of colonisation and destruction of wood, are of critical significance for infection. Temperature and pH can be the limiting factor for the development of numerous competitive microorganisms colonising the same nutritive medium. The main aim of this investigation was to discover the optimal conditions of the tested fungus development, in order to compare it with the developing conditions of other competitive microorganisms, to discover the possibilities of a spontaneous infection in natural conditions, in the stands or at storages. In order to estimate the impact of this species on the succession of microorganisms in the same medium, the influence of L. edodes was investigated on the change of medium pH during its growth by using unbuffered nutritive media. The impact of medium pH on the fungus was investigated by using buffered nutritive media with stabile pH values during the test. The results show that the conditions of temperature and pH, which are convenient for the fungus L. edodes, are normally present in nature, and that from this point of view this fungus could easily perform spontaneous infection. However, at the same time, optimal conditions for the growth of this fungus are also very convenient for the development of other numerous decaying fungi, so the issue of the success of infection is viewed in the light of competitive relations of microorganisms in the same nutritive medium.*

Key words: *Lentinus edodes*, shiitake, growth, temperature, pH.

1. INTRODUCTION

To elucidate further the nature of the fungus *Lentitnus edodes* as oakwood destructor, we researched the basic conditions which determine and enable the fungus to cause infection. In field conditions, i.e. in the stand and oak wood as the microsite for infection by spores, by all means the basic determinants of this process are the temperature, medium pH, nutrient status in the medium, inoculum level, virulence and the competition of other microorganisms (Frederick, H.B., Lombard, F.F. 1978; Humphrey, C.J., Siggers, P.V. 1933). In this sense, the effect of temperature and the concentration of hydrogen ions in the medium are researched, as they are basic parameters of the environment in which the entire process of infection and rot development goes on in a period of time (Fries, N. 1950; Fukada, K., Okayasu, Y., Haraguchi, T. 1981).

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Mycelial growth was researched at different temperatures to determine the range in which the fungus can form the mycelium, to the extent in which it can develop the adequate physiological activity. In other words, the temperature at which the nutrients from the medium are best utilised, i.e., in case of wood, when it can decompose the wood constituents responsible for strength properties - lignin, pulp and polioses, which together account for 97 – 99% of wood volume (Grosser, 1985).

The concentration of hydrogen ions is, along with food, probably one of the most important factors which define the dynamics of fungus development on the medium (Krstić, M. 1962). It affects the growth and metabolism of wood rotting fungi, in the same way it affects the development of all plant species (Rypaček, 1966). The medium acidity can stimulate or inhibit the growth of lignicolous fungi, and the change of pH value has a significant effect on the rate of nutrient consumption and the medium decomposition (Frankland, J.C., Hedger, J.N., Swift, M.J., 1982). The medium acidity also affects the enzyme system of the fungi which supports the vital demand of the organism for food. Cartwright, K.St.G., Findlay W.P.K. (1946) report that the weak acid medium (pH 5 to 6) is optimal for the growth of the greatest number of wood rotting fungi.

On healthy wood with pH mainly about 7, many fungi succeed in developing the germ tubes and mycelium. In further development, they cause the change of pH themselves, adapting it to their optimum, or the infection of wood can occur only after other micro-organisms, which tolerate the neutral pH for initial development, reduce the pH of the medium and in this way make it more favourable for their development. Many wood rotting fungi produce organic acids in significant quantities and thus the medium is acidified. Epixylous fungi, by wood decomposition (oxidising and hydrolysing of wood constituents) increase its acidity by oxalic acid which is formed in these processes (F. S. Wolpert, 1924). This group of wood rotting fungi includes *Lentinus edodes*, better known as Shiitake, the fungus better known for its medicinal effect and as culinary delicatessen, than as the wood rotting fungus (Hobbs, C. 1986; Lazarev, V. 2003).

In this way, the nature regulates the sequence and order of micro-organism infestation of nutritive media, which along with the vitality of host plant, degree of parasitism and the fungus nutrition, present one of the most important, almost decisive parameters in the process of wood colonisation (Otjen, L., Blanchette, R.A. 1984; Rayner, A. D. M., Boddy, L., 1998). This process regulates the connection or succession of species in the same medium.

2. MATERIAL AND METHOD

Temperature

The dikaryotic mycelium *Lentinus edodes (Berk.) Sing.* was isolated from the fruiting body. Two isolates were used in the research: AV (originating from Italy) and T 72 (originating from USA).

The mycelial growth rate was researched by standard method, in plastic Petri dishes (D = 90 mm), on malt (5 Bé) and agar (2%) medium, at pH = 6.0 and in full darkness. Mycelial growth was monitored at the temperatures of 4, 8, 12, 14, 18, 22, 29 and 32^0 C in five replications. The inocula were plated, because of the fast growth of mycelium, at the edge of Petri dishes. Mycelial growth was marked every 24 hours in the direction of the dish radius and left and right at the angles of 22.5^0 (three directions). It was expressed as the mean value in all five replications in millimetres per day.

pH

Research of the effect of medium pH on growth and production of *L. edodes* mycelium mass

The effect of different constant medium pH values on the mycelium development of the tested *L. edodes* strains (AV and T 72) was researched on buffered nutritive medium. To make the quantity of nutrients in the particular parts of buffer homogeneous, buffer system was prepared by the presented Wolpert's method, which was used by several authors (Mirić, 1993; Rypaček, 1957). By mixing different volumes of 0.3 molar solutions of phosphates - phosphoric acid (H_3PO_4), potassium dihydric phosphate (KH_2PO_4) and potassium hydrogen phosphate (K_2HPO_4), the media with different pH values were obtained, but with the same phosphate quantity, so that their different quantity cannot affect the results. Five series of phosphates of 75 ml were obtained, which were poured in 100 ml Erlenmeyer flask (Scheme 1).

Scheme 1: Prescription for the preparation of buffered medium

Series number	Parts 0.3 M solution (ml)			Parts of solution double concentrated malt (10 Bé) and agar 4% (ml)
	H3PO4	KH2PO4	K2HPO4	
1	13.0	62.0	-	75
2	4.6	70.4	-	75
3	-	74.7	0.3	75
4	-	62.5	12.5	75
5	-	16.8	58.2	75

Separately, 375 ml of double concentrated malt and agar medium was prepared and poured (by 75 ml) in 5 Erlenmeyer flasks of 100 ml. This medium was autoclaved separately from 0.3 molar solutions of phosphates and after pH control, it was mixed with them in aseptic conditions. After sterilisation, pH was controlled to determine the stability of buffer systems. In this way, the medium of standard concentration of sugar (5 Bé) and agars (2%) was obtained, with physiologically equal percentage of buffer (0.15 M).

The prepared buffered medium was poured (by 20 ml) in plastic Petri dishes (D = 90 mm). Three replications (2 strains x 5 series x 3 replications = 30 Petri dishes) were used for each fungus strain and each tested pH value. Inoculation was performed in the sterile laminar chamber, by mycelium fragments of square form (5 x 5 mm), which were plated at the edge of Petri dishes. The cultures were kept in the thermostat, at the temperature of 21^0C. Mycelial growth was marked every 24 hours in the direction of the dish radius and to the left and right at the angles of 22.5^0. Average daily growth was determined as the mean value of growth in 3 directions, and the number of days depended on the rate of fungal growth at the defined (constant) pH values of the nutritive medium.

To check the stability of the buffer system (control of medium pH at the end of the research), simultaneously with the establishment of the test series, the liquid medium (without agar) was also prepared, which was inoculated and incubated under the same conditions. At the end of the experiment (after 22 days), medium pH values were measured by pH-metre and the dry weights of the mycelia were also measured.

Research of the effect of** L. edodes **mycelium on the change of the medium pH

The effect of the fungus ***L. edodes*** (strains AV and T 72) on the change of the medium pH was researched on unbuffered (liquid) medium by Schmidt and Liese method (after Mirić, 1993). 1,300 ml of double concentrated malt medium (10 Bé sugar) with distilled water was prepared. Of this quantity, 204 ml was poured into each of 6 Erlenmeyer flasks, volume 300 ml (for 6 series) and it was supplemented with the solution of distilled water and 1 M HCl, i.e. 1 M NaOH by the presented prescription (Scheme 2). In this way, the necessary quantity of liquid nutritive medium of standard malt concentration (5 Bé) sugar was obtained.

Scheme 2: Prescription for the preparation of unbuffered (liquid) medium

Series number	*Parts of solution (ml)*		*Distilled water (ml)*	*Parts of solution of double concen-trated malt medium (10 Bé) (ml)*	*medium pH*	
	M HCl	*M NaOH*			*before sterilisation*	*after sterilisa-tion (initial pH)*
I	*4.80*	*-*	*200*	*204*	*4.9*	*4.8*
II	*0.28*	*-*	*204*	*204*	*5.7*	*5.4*
III	*-*	*-*	*204*	*204*	*5.7*	*5.4*
IV	*-*	*0.40*	*204*	*204*	*5.8*	*5.5*
V	*-*	*1.62*	*202.8*	*204*	*5.9*	*5.6*
VI	*-*	*12.80*	*194.8*	*204*	*6.7*	*6.1*

Before sterilisation, pH value of each series was measured. From each series, 60 ml of medium was poured in 6 Erlenmeyer flasks, volume 100 ml (3 replications for each fungal strain). So, the medium from 6 series was poured in 36 Erlenmeyer flasks which were autoclaved for 20 minutes at the temperature of 120 ± 1 ^{0}C and pressure of 1.4 b. After sterilisation, pH values were re-measured and they were treated as initial.

Inoculation by the fungus *L. edodes* (strains AV and T 72) was performed in the laminar chamber, by mycelium fragments of square form (5 x 5 mm). For each series (initial value of pH), the media in 3 Erlenmeyer flasks were inoculated.

The incubation lasted for 22 days at the temperature of 21^{0}C. During incubation, the change of pH was measured every 7 days. For each measurement, 10 ml of the medium was taken with sterile syringes with needles in aseptic conditions, poured in cuvettes, and pH value was measured by pH-metre. At the end of the experiment (after 22 days) the dry weights of the mycelia from all Erlenmeyer flasks were measured. The mycelium was filtered by water vacuum pump on the previously measured oven dry filter paper of circular form (D = 85 mm) and then kiln dried to oven dry state and measured by digital balance. Filter paper and mycelium were dried at 104^{0}C, and before control measurements, the samples were placed in excicator with silica gel, to prevent the absorption of air humidity.

3. RESULTS AND DISCUSSION

Temperature

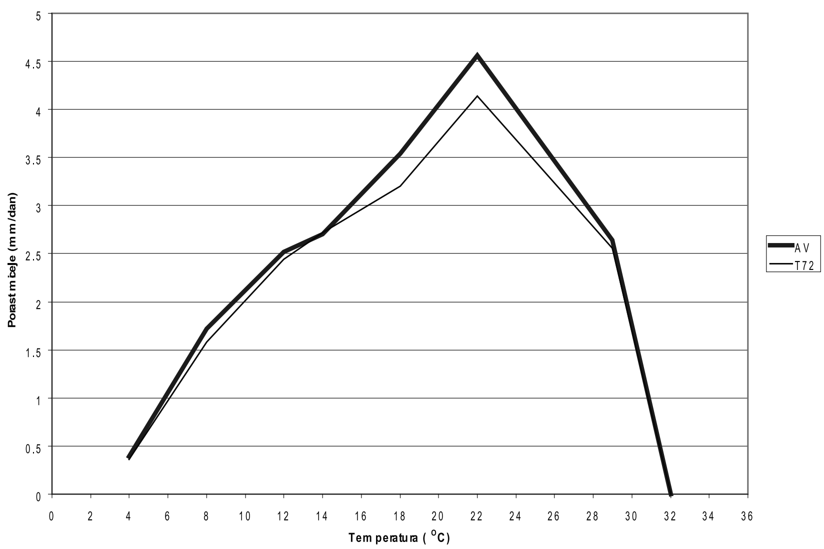
Table 1 and Diagram 1 present the average daily mycelial growth of the fungus *Lentinus edodes* (strains AV and T 72) at the temperatures of 4, 8, 12, 14, 18, 22, 29 and 32^0 C.

The results presented in Table 1 and Diagram 1 show that the strain AV has faster mycelium growth than the strain T 72 at almost all tested temperatures. At the temperature of 32^{0}C there was no mycelium growth of any strain even after 25 days. This temperature was lethal, which was confirmed by the mycelium establishment on the fresh medium and exposure to the optimal temperature. At the temperature of 4^0 C, both strains had very slight growth. The optimal temperature for mycelium growth of the tested *L. edodes* strains was 22 ^{0} C, which is within the range of the optimal temperatures for the development of most wood rotting fungi which infest oaks. The average daily mycelial growth of *L. edodes,* strain AV was 4.56 mm and somewhat less - 4.14 mm for strain T 72.

Table 1: Total average daily mycelial growth of the fungus Lentinus edodes (strains AV and T 72) at different temperatures

Temperature (0C)	Strain	Daily mycelial growth (mm/day)
4	AV	0.39
	T 72	0.36
8	AV	1.72
	T 72	1.58
12	AV	2.52
	T 72	2.44
14	AV	2.70
	T 72	2.72
18	AV	3.54
	T 72	3.20
22	AV	4.56
	T 72	4.14
29	AV	2.64
	T 72	2.56
32	AV	0.00
	T 72	0.00

Diagram 1: Growth of L. edodes mycelium at different temperatures



pH

The effect of medium pH on growth and production of *L. edodes* mycelium mass

The results presented in Table 2 show that the mycelia of both shiitake strains develop in all series with acid reaction (initial pH 3.0 to 4.8) except in the series 5, which had weak alkaline reaction (initial pH 7.6). The poorest growth of both strains occurred in series 1 (stronger acid medium, initial pH 3.0). In the series 2, 3 and 4, both strains had very similar growths, but the strain AV had the fastest growth in series 4 (initial pH 4.6), and the strain T 72 in series 2 (initial pH 3.5).

Table 2: Average daily growth (mm /day) and the dry weights of L. edodes (AV and T 72) mycelia (g) on buffered nutritive media

Series number	Strain	medium pH			Average daily growth of mycelium (mm/day)	Dry weight of mycelium (g)
		buffer pH	pH after sterilisation (initial pH)	pH at the end of the experiment		
1	AV	3.1	3.0	3.2	2.43	0.090
	T 72	3.1	3.0	3.3	2.37	0.066
2	AV	3.6	3.5	3.8	3.23	0.141
	T 72	3.6	3.5	3.9	3.37	0.174
3	AV	4.9	4.8	4.3	3.20	0.163
	T 72	4.9	4.8	4.4	3.07	0.236
4	AV	4.7	4.6	4.3	3.33	0.232
	T 72	4.7	4.6	4.2	3.13	0.177
5	AV	7.7	7.6	7.4	0.00	0.000
	T 72	7.7	7.6	7.5	0.00	0.000

The dry weight of mycelium in strain AV was the greatest in series 4, where this strain also had the fastest mycelium growth, while the greatest mycelium weight of strain T 72 occurred in series 3 (with initial pH 4.8). Except the series 5, on which there was no mycelium growth of any strain, both strains had the smallest mycelium weight in series 1, with the poorest growth of mycelium. However, although in series 5 no mycelia of any strain developed for 24 days, this pH value was not lethal for the fungus, because after plating the fragments on the medium with the optimal pH (6.0), the cultures developed 7 days after plating. These cultures needed 19 days to overgrow Petri dishes.

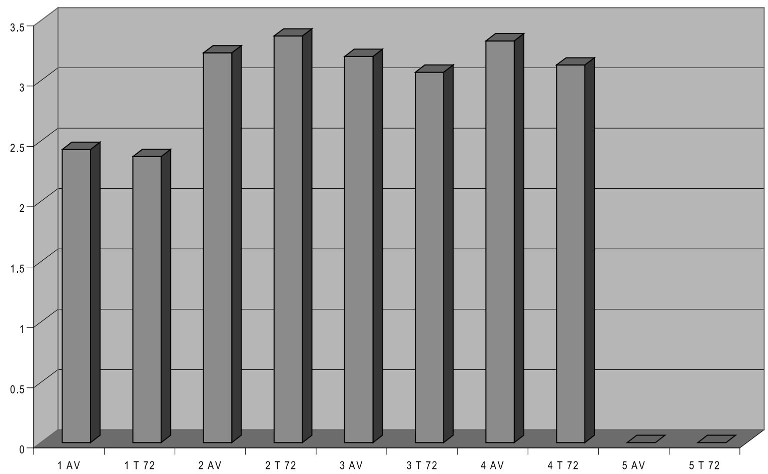


Diagram 2: Daily growth of L. edodes mycelium, strains AV and T72, on buffered media

pH control and measurement of mycelium dry weight was performed in liquid media. Total measurement of mycelium growth on solid media lasted for 22 days for series 2, 3, 4, 5, and 26 days for series 1. pH control (to check the stability of buffer system) and the mycelium dry weight was measured in liquid media 22 days after inoculation for all series. It was found that both strains changed their initial pH values, changing the pH of the medium from 0.1 to 0.5 towards the optimal values which ranges within the tolerant values, so it can be concluded that all buffer systems were stable during the experiment.

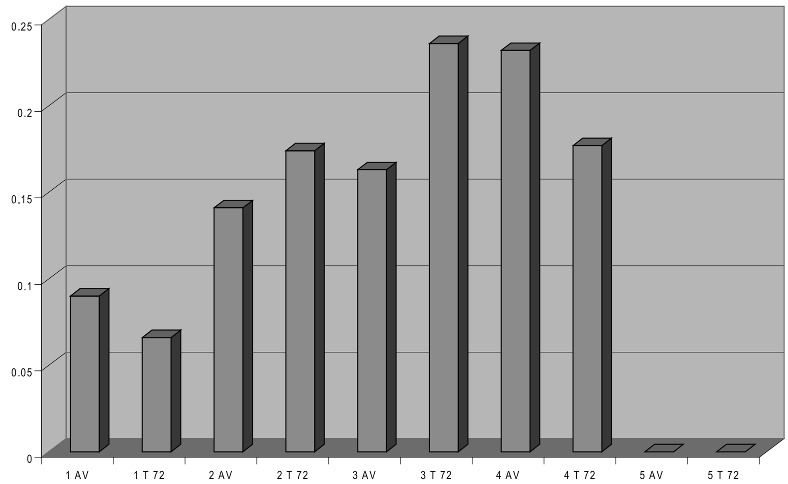


Diagram3: Dry weight of L. edodes (AV and T72) mycelium on buffered media

The effect of *L. edodes* mycelium on the change of nutritive medium pH

Table 3 presents the change of pH of malt medium of standard concentration, under the effect of *L. edodes* mycelium.

Table 3: Change of medium pH value under the effect of L. edodes (AV and T 72) mycelium after 7, 14 and 21 days

Series	Strain	Initial pH	Change of medium pH after ... days				pH at the end of the experiment	Dry weight of mycelium (g) after 21 days
			7	14	21	Total		
I	T 72	4.80	-0.03	-0.10	-	-0.13	-	0.031
	AV		-0.10	-0.03	-0.02	-0.15	4.65	0.058
II and III	T 72	5.40	-0.16	0.00	-0.48	-0.64	4.76	0.041
	AV		-0.08	-0.07	-0.27	-0.42	4.98	0.039
IV	T 72	5.50	-0.12	-0.08	-0.15	-0.20	4.95	0.044
	AV		0.00	-0.10	-0.65	-0.75	4.75	0.040
V	T 72	5.60	+0.03	-0.16	-0.60	-0.60	5.00	0.037
	AV		0.00	-0.13	-0.60	-0.73	4.87	0.049
VI	T 72	6.10	-0.17	-0.20	-0.80	-1.17	4.93	0.073
	AV		-0.12	-0.35	-1.33	-1.80	4.30	0.079

Note: Series II and III are presented together as the average because the initial values of pH were the same.

At the end of the experiment, after three weeks of the fungal effect, pH value of the medium was reduced to 4.30 - 5.00, which means that the mycelia of both strains of shiitake tended towards these pH values in this phase of growth. It is known that fungi very often, depending on the development phase (germination of spores, growth of mycelium, formation of fruiting bodies, sporulation) can have different needs for different values of medium pH. Thus for example, for the germination of spores, the fungus tolerates a more acid medium, while in the phase of formation of fruiting bodies, this need changes and often fungi prefer a mild acid medium, or a medium close to neutral. This phenomenon, of course, differs from species to species, and can be significant especially in the production of fruiting bodies for commercial purposes. This is also the case with the fungus *L. edodes*, because it is known from practice and experience that this species fructifies best on the media of mild acid reaction – pH about 6 (Dittberner D. 1988). It should be emphasised that this should be taken into account both for this fungus and for other fungi, because pH medium is often a decisive factor in the process of infection, colonisation of the medium, or development of decay, its appearance, course and dynamics.

4. CONCLUSION

The temperature of 22 ^{0}C at which both tested strains of the fungus *L. edodes* had the fastest growth, actually presents the element of our regional climate. However, simultaneously, it is the optimal temperature for the growth and development of many species of wood rotting fungi, so it should be taken into account that in the field, *L. edodes* has a great number of competitors for food and space, which also develop in their favourable temperature conditions.

The change of pH of the medium on which the cultures of both tested strains of *L. edodes* developed, ranged in the direction of mild acid reaction (4.3 to 5.6), which indicates that it prefers the mild acid medium, just like the majority of wood rotting fungi. This fact, in addition to temperature, indicates that *L. edodes* in competitive conditions with other wood rotting fungi, infests the medium with equal chances for success, at least regarding the temperature and the concentration of H-ions.

On the media with acid reaction, *L. edodes* developed the hyphal colony. This indicates that the lower pH values, which could occur in field conditions as the consequence of the development of some competitive species, would not inhibit or prevent the growth of *L. edodes* mycelium. The alkaline reaction of the medium however, is not favourable for this fungus, and it stops growing already at pH value of 7.6. If pH is lowered again, the fungus can continue its growth, i.e. it does not lose the vitality in mild alkaline media.

Bearing in mind the results of the research of the effects of temperature and H-ion concentration on mycelium growth and production of the fungus *Lenten's eddoes,* as well as the change of medium pH under the effect of this fungus, it can be concluded that the tested species was neither favoured nor inhibited by environmental factors in the potential successful colonisation of the nutritive medium in field conditions, compared to competitive wood rotting fungi. The phenomenon of microorganism competition in the same medium, growth inhibition or the occurrence of antagonism can result from the metabolism of antagonistic species of fungi, excretion of mycotoxins or antibiotics before the growing front of the mycelium, and the susceptibility, i.e. reaction of the competing species.

The rate, course and consequences of the decay of wood as the medium and the source of food depend directly on this phenomenon, and also of the wood as a very important raw material for processing in the country economy, which, because of its organic origin, presents the food for a great number of organisms and microorganisms. For this reason it is necessary to investigate the competitive relations of this and other competing species of wood-rotting fungi in the controlled conditions of the so-called mixed cultures, under the conditions of moisture, temperature and concentration of H-ions which suit all species of antagonistic fungi.

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SECTION 5

ROLE OF FORESTRY AND ENHANCEMENT OF NATURAL RESOURCES AS A PART OF FOREST POLICY

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Abstract: *In the past decade, the European forestry modified considerably from the exclusive production of wood to a wide spectre of goals and services related to forest, from felling to landscape management and recreation tourism, and from biodiversity conservation to sustainable utilisation of secondary forest products. Most of the above goals and services depend on the ecological processes at the level of natural resources, where forestry and forest management must be taken into account in a wider context. Concurrently with the development, in the same trend with the development of the society, forests and forestry are not any more an exclusive domain of the specific professionals. As a part of this development, strict sectoral approach to forest management might not be able to meet the increasing, different demands from the forest. The integrated approach to land use will be increasingly topical. Although the increasing interest is the conservation of biodiversity and the amenity values, e.g. the European network Natura 2000, as well as the mitigation of the climate changes, many forest owners (state and private) are not ready for such actions. The economic effects do not often coincide with the prevailing interest. As the result, forestry with all of its aspects regarding integrated land use and enhancement of natural resources is often seen as something that is slowly adapted, as a conservative factor. The presented issues of the integrated role of natural resources – forests are focused on what they direct, what the objectives are, and what the role of forests is in the integrated estimate. Is the role of the forest sector decreased, where is the role of forests and natural resources in the integrated land use, where and how forest sector can benefit from the new potentials and roles.*

Key words: forest, policy, environment, resources, nature

1. INTRODUCTION

Natural resources – forests

The thesis on the definition of the territory dates back from the creation of modern states, the authority that determines and regulates the rights of the national resource, forests.

In the past period, government interventions were mainly directed to monitoring the work of forest owners and forest users, as well as to socio-economic relations in this domain. The allocation of profits was specially treated and it included the state intreventions, because the very existence of resources is questionable without a mechanism for the regulation and improvement of resources. One of the potential strategies is to determine the company or the private owner under the assumption that they have an economic incentive to keep the resource long-term, renewable and to benefit from such actions. For this reason, it is very difficult, even impossible to regard natural forest resources as the "private ownership rights". The approaches, such as the short-term "use and go", cannot be grounded. In this way, some users of the resource have the

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advantage, because the used up resources remain, and the subsequent users pay the bills and take over the responsibility for the damage. Later on, the users will, by all means, tend to get the maximum, and the end result is the rapid and non-renewable devastation of the resource which leads to the "tragedy of the favourable" (Gluck *et al.* 2005a).

Recently, the traditional approaches "command and control" (the emphasis on the complete public ownership) change and give the opportunity to more market-based, local or decentralised approaches (Gluck *et al.*, 2005b).

Compared to the processes of resource management in the past, today these processes develop with greater attention paid to the "external effects" of log production, secondary forest products, etc. According to the prevailing public opinion, the forest sector policy development and institutions must accept the facts that log production does not exclude or reduce the possibility for the development of other activities, such as: seedling production, hunting and fishing, etc. On the other hand, private forest owners should be rewarded by the compensation from the state for the "secondary profit" they contribute by their work on the maintenance of forest sites, conservation of ecological values, etc. The new approaches to the natural resource management are needed, they should ensure the adequate approach to multi-functional forest values, without any drastic expansion of the regulations, which characterised the traditional measures in the past.

2. ANALYTIC TOOLS OF FOREST POLICY

There are three interdependent factors regarding the policy creation by the bottom-up approach: networking policy, as a new concept in forest resources management; policy of the expertise; the cooperative policy of development and management.

The new concept of forest policy making – Already in the sixties, the limitations were observed in the traditional idea and in the administrative structures, policy instruments. The new social movements, especially all the more significant issues of nongovernmental organisations which deal with the protection of natural resources at the global level, created the so-called *non-conventional form of protest* against the forest policy of that time, such as the boycotts of the buyers in the countries which import logs. The protests consisted partly of the public presentation of the facts on the illegal trade of logs, or on the resistance to international efforts for biodiversity conservation. There are two forms of management reported in the literature: *old governance and new governance* (Gluck *et al.*, 2005c). In the *old governance* the state "supervises" the society and economy as a part of its administrative apparatuses, determining the goals and market priorities. *New governance* refers to the sustainable coordination and coherence between numerous and versatile private and state factors and participants in economy, with different goals and intentions.

The idea on new governance occurred because of the disadvantages in the state hierarchical style of solving the problems of forest policy, which is characterised by many complex questions and with the presence of a high number of participants in the processes which require the realisation of their goals in the adequate way (Gluck *et al.*, 2005d).

The policy goals will perhaps be better realised by directing all the capacities of the forest policy participants to become the policy creators and not the *obser*vers of the implementation of a hundred of old-time regulation instruments.

The experiments with the new governance are reflected in different institutional forms. The most significant ones, which reflect forest policy, are: international considerations of forestry; national forest programmes; market oriented mechanisms of forest certification; decentralisation; self-organising.

3. INTERNATIONAL SIGNIFICANCE OF FORESTRY

This idea involves the international commitment, by which each country has sovereign right to manage, protect and develop its own forest resources pursuant to its own policy measures. On the other hand, each country is obliged to participate in the international forums and to respect the international regulations.

A country can, because of its interests in profit making, direct the maximum potentials to wood production and neglect the other commitments regarding nonwood products, or the improvement of natural resources. Regional or global forest problems can occur when such management starts creating transboundary effects. For example transboundary air pollution is when the pollution produced in one country is transmitted to the surrounding countries thus causing forest dying. This means that forest management in one part of the world can affect the other parts of the world and human well being. For this reason, the fundamental changes are necessary in the national system of decision making which can influence the natural resources.

The United Nations Conference on Environment and Development in 1992 was of key importance to forest policy because of the agreement on the important preconditions for the sustainability of the European Conventions. These preconditions include the principles of sustainable management, protection and sustainable development of all forest types.

Monitoring and reporting are the building blocks for the assessment of the success of the international agreements on forestry (UNFF- United Nation Forest Forum and CPF – Collaborative Partnership on Forests), the development of the parameters for legally binding instruments in forestry, determining the future role of the international forest dialogue. Forest principles constitute the following definition of the sustainable management of forest resources: "Sustainable management of forest resources and forest lands should be aimed to fulfil social, economic, ecological, cultural and spiritual needs of current and future generations". The needs include: forest products and services, such as wood and wood-based products, water, food, cattle food, medicine, fuel, shelter, jobs, recreation, wildlife habitats, landscape diversity, carbon sinks, and other forest products.

The definition of sustainable forest management can be rather widely conceived. The countries involved in the regional solving of forest issues develop their own operational definitions of SFM - sustainable forest management, as well as a set of indicators and criteria at the national level. Today there are nine criterion/indicator processes: Montreal process, among which are: the Central American incentive, Ministerial Conference on the Protection of Forests in Europe (MCPFE), as well as numerous other organisations.

4. NATIONAL FOREST PROGRAMME

According to the definition of the Resolution of Ministerial Conference on the Protection of Forests in Europe (MCPFE) National forest programme constitutes a participatory, holistic, inter-sectoral and iterative process of policy planning, implementation, monitoring and evaluation at the national level in order to proceed towards the further improvement of sustainable forest management

The realisation of management of forest processes is carried out by the formulation and implementation of the National Forest Programme. The goal is, by all means, the sustainable forest management of natural resources, the conservation and the protection of natural resources aimed to fulfil social, economic, ecological, cultural and spiritual needs of current and future generations NFP - National Forest Programme, is the planning instrument containing the ideas of the national interests for the sustainability of forest natural resources at the national level, with the long-term orientation and better coordination, through numerous basic principles and elements, which replace the traditional technocratic-oriented planning (Gluck 1999). The implementation of such principles requires the creation of the favourable climate of mutual confidence, which keeps the participants in the negotiating process on forest issues in the permanent participatory dialogue.

The process of NFP elaboration in Serbia started in 2003, with the beginning of the FAO project, as the technological cooperation programme "Institutional development and capacity building for National Forest Programme in Serbia". NFP in agreement with the goals of the project "forestry sector Development in Serbia", encompasses the development of forest policy, which has already been adopted (sectoral strategy), forest and hunting legislation, forest action plan and programme, mechanism for their monitoring and the reform of state forest institutions and forest service.

5. INTEGRATED MANAGEMENT OF FOREST RESOURCES

National Forest Programme encompasses the issues of management and administration of forest resources, with special emphasis on the integrated management of natural resources. Most European countries have already implemented such an approach of governance and integrated management of forest resources. Integrated management of natural resources and similar approaches are more efficient than the individual approaches of one-sided disciplines in dealing with the complex issues of resources. The procedure of integrated management of natural resources includes several disciplines and involves different stakeholders in space and time. These approaches refer to the identification of the favourable strategy of natural resource management in the aim of sustainable supplies of natural resources, as well as the flow of goods and services, on the one hand, and the sustainable state of ecological values, on the other hand.

Forests as natural resources are complex systems, and can be used for various purposes. Integrated management of forest resources includes all forest resources, components and services in their interaction. According to this principle, the planning of protection or conservation of the vegetation cover, wildlife, soil, water and cultural values, coordinate in the integrated way. The coordination between the programme of protection and utilisation of forest resources can be completely realised if there is such coordination. The services offered by resources, including the recreation, visual quality of landscapes, production of drinking water, pure air, carbon sequestration, can be better realised by the integrated approach than by the approach which deals with all the above elements separately.

The utilisation of forest resources and the effect of professionals in the particular spheres of forestry have increased, compared to the past period. The managers, hydrologists, biologists, hunting experts, landscapists, the public and the professionals in the nongovernmental organisations, all have their roles in forest resource management depending on their specialties and knowledge.

Another task of the integrated management of forest resources is the establishment of the permanent concept and approach to zoning of land use. Land use planning can help in the establishment of interests and neutralise the conflicts: log production in one zone, wildlife in the special habitats, specific forms of recreation also on the determined areas.

6. FOREST SECTOR – OPPORTUNITIES AND BENEFITS

The development and the organisation of production and trade of nonwood products, services and benefits from forest resources, has recently become all the more significant along with the production of wood volume, as one of the main activities of the forest sector.

6.1. Nonwood forest products

The definitions of forest nonwood products differ. Depending on the part of the world where such products are harvested, traded or used by the population, the definition of nonwood forest products is reduced to the idea that social, cultural, economic values of the states increase with the sustainable utilisation of natural resources.

Nonwood products and services of the forest sector are becoming a form of industry (Duchesne *et al.* 2001), with the increased interest of the society in socio-economic development, biodiversity conservation, improvement of natural resources and reinforcement of national identity. History knows many examples of plants and animals that are commercially extinct because of overharvesting. In practice, the great success and development of the NTFP industry at one locality and time period may deplete natural stocks and reduce the sustainability of this resource.

Therefore, the promoters of the NTFP "industry" and services must recognize the fact that they also carry the responsibility, of course with all other participants in the management of forest resources to preserve the stability of this resource.

One of the methods of control of nonwood forest products is certification at the international level. Certification has three roles: First, it must ensure that the harvesting or production of nonwood forest products is sustainable while biodiversity is conserved. Second, as many nonwood forest products are food products or medicines, the harvesters must guarantee that the nonwood forest products are free of pesticides or environmental contaminants in a way that is similar to the certification of agricultural products. Third, certification must also address a concern for the socioeconomic status of the people who depend on nonwood forest products for their livelihood or for supplementing their income.

The possible recommendations for the development of the activities addressing nonwood forest product are: Increase the knowledge at the local, regional and the state level; Governments and their agencies need to support forest communities, local institutions, associations and individuals in the research and development of NTFP opportunities; The development of small and medium enterprises dealing with harvesting, production, distribution and trade of nonwood forest products should be emphasised; Governments should support local communities to ensure biodiversity conservation in accordance with the needs of forest communities at the national and international levels, the implementation of pilot studies, which will coordinate the public sector, small and medium enterprises in the sphere of nonwood forest products and local institutions to direct the development and sustainability of nonwood forest enterprises.

6.2. Recreation in forests – tourism in nature

National budget of the developed countries is significantly increased by the income realised by one of the forest sector activities, recreation in forest. The research which was performed with the aim of finding out how many visitors used forest resources for different types of recreation, resulted in the data which will, by all means, serve for the planning of natural resource management. The resulting information shows that the income realised by this activity increases in the forest sector every year. For example: The US Forest Service carried out the research under the title: National Visitor Use Monitoring Program. The aim of the research was to find out the value of the income realised by such services of the forest sector, and other data: how many people recreate on the forest, what activities they do, how much they spend, and how satisfied they are with the forest services, etc. This Programme used the best available methods in science and strategic planning analysis. After four years of research, they obtained the encouraging data that the integrated forest management resource can be directed to recreation tourism. The research was carried out in the area with 25 % of the total area under forest cover. There were 155 thousand interviews; 22 thousand workdays were spent in the fieldwork.

The definition and the basic initial thesis of the research is the principle that a forest visit is the entry of one person in forest area to participate in recreation in a period of time. Visitors usually come to forest lands for physical exercises, viewing natural features, as well as for walking and relaxation. There were 204 million visits to forest complexes in tourist pursuits. The most often chosen activities in forest are: viewing natural features, relaxation walking, viewing wildlife and driving for pleasure through the forest. Skiing is also very popular. In further text we shall list the activities in forests which were assessed: bicycling, cross-country skiing, camping, skiing – downhill skiing, driving for pleasure through forest, fishing, harvesting forest products, hiking/walking in forest, horseback riding through forest, hunting, motorized water activities, nature study of rarities, non-motorised water activities, off-highway vehicles, other motorised activities, other nonmotorised activities, picnicking, primitive camping, relaxing-walking, use of resorts, snowmobiling, viewing natural features, viewing wildlife, visiting historic sites, etc.

Final data of the research show the impressive results: the users of forest resources and the recreation visitors made 205 million recreation visits each year during four years. They spent 7.5 milliard dollars in the settlements and resorts located in the vicinity of the forests.

There were 175 million visits for relaxation and people viewing the forest landscape. Recreation in forests provided a high contribution to physical and mental health of the population, as well as a significant economic gain for the population and the communities located in the vicinity of forest resources. In addition to the data regarding the users, the report gives the data which are significant for the managers and management of forest resources, the guidelines for further improvement of forest resources. The comprehensive data will help the resource managers to better understand the requirements and habits of the customers, to identify the forest recreation market demands and needs, target groups of users, i.e. the most attractive natural resources.

Several studies in this field were published in Europe. The latest research is COST E 33, under the title: "Recreation in forest and tourism in nature (Bell 2005).

The Project started in 2004, and it will end in 2008.

The research covers the important disciplines of forestry by the implementation of multi-disciplinary approach of forest and landscape professionals, specialists for rural development - spatial planners, economists, statisticians and tourist experts. The tasks of the project COST E 33, and the working groups which work on this project, are to determine:

- the value and benefits of recreation in forests and tourism in nature
- the needs and demands for recreation in forest and tourism in nature
- planning, design and management of the recreation in forest and tourism in nature.

The aim of the Project is not only to establish the values and demands of recreation tourism in forests, but it also has a vision of the team which should deal with such issues, and the harmonisation with the modern EU standards. Primarily this is the gender ratio in the research team, the multi-disciplinary approach, and the determination of the actual state, reality in forestry, the participation of the young doctorants researchers, as well as the participation of the public and the experts from practice.

7. CONCLUSION

In the past period, government interventions were mainly directed to monitoring the work of forest owners and forest users, as well as to socio-economic relations in this domain. Compared to the processes of resource management in the past, today these processes develop with greater attention paid to the "external effects" of log production, secondary forest products, etc. The new approaches to the natural resource management are needed, they should ensure the adequate approach to multi-functional forest values. The most significant forms which reflect forest policy are: international significance of forestry; National Forest Programmes; market oriented mechanisms of forest certification; decentralisation; self-organising. Each country has sovereign right to manage, protect and develop its own forest resources pursuant to its own policy measures. On the other hand, each country is obliged to participate in the international forums and to respect the international regulations. Forest principles constitute the following definition of the sustainable management of forest resources: "Sustainable management of forest resources and forest lands should be aimed to fulfil social, economic, ecological, cultural and spiritual needs of current and future generations". According to the definition of the Resolution of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) National forest programme constitutes a participatory, holistic, inter-sectoral and iterative process of policy planning, implementation, monitoring and evaluation at the national level in order to proceed towards the further improvement of sustainable forest management. National Forest Programme includes the issues of governance and management of forest resources with special emphasis on integrated management of natural resources. The procedure of integrated management of natural resources includes several disciplines and involves different stakeholders in space and time. These approaches refer to the identification of the favourable strategy of natural resource management in the aim of sustainable supplies of natural resources, as well as the flow of goods and services, on the one hand, and the sustainable state of ecological values, on the other hand. Along with the production of wood volume, as one of the forest sector activities, the benefit from nonwood forest products has become all the more significant in the last years. National budget of the developed countries is significantly increased by the income realised by one of the forest sector activities, recreation in forest. Recreation in forests provided a high contribution to physical and mental health of the population, as well as a significant economic gain for the population and the communities located in the vicinity of forest resources.

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PROCEDURE OF ACCREDITATION OF TESTING LABORATORY

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Abstract: *Accreditation certifies that the organisation meets all formal requirements and that it is competent for the conformity assessment. Within the accreditation system, the Accreditation Body determines the competence of the applicant for the conformity assessment, e.g. of the laboratories for testing. The criteria for the laboratory accreditation are regulated by the standard SCS ISO/IEC 17025:2006, the Law on Accreditation and the conditions for meeting the requirements prescribed by the Accreditation Body, as well as by other provisions and national and international standards and directives. The accreditation certificate is granted after the stringent accreditation procedure has been passed. The initial activities include: the letter of intention addressed by the applicant who wants to accredit the laboratory, followed by the application for accreditation, with the necessary documents demanded by the Accreditation Body. The organisation should plan the time of application, which means that it should perform all the necessary preparations of the laboratory (for the defined scope of accreditation) to fulfil the requirements of the Standard and other requirements. The key activities of the accreditation procedure are: preparation for assessment, the assessment, report on the assessment, decision on the accreditation and granting the accreditation certificate. The decision on accreditation can be positive or negative. If the laboratory is accredited, the accreditation procedure also includes the regular annual inspection by the Accreditation Body and the potential extraordinary inspections. The accreditation certificate is valid for four years after which it is followed by the re-accreditation.*

Key words: testing laboratory, accreditation, requirements, accreditation procedure

1. INTRODUCTION

Accreditation certifies that the organisation meets all formal requirements and that it is competent for the conformity assessment. Within the accreditation system, the Accreditation Body determines the competence of the applicant for the conformity assessment, e.g. of the laboratories for testing. In addition to laboratories, Accreditation Body accredits also the control organisations, certification bodies, etc.

At the European level, the European Cooperation for Accreditation – EA has adopted the principle: *one European country – one Accreditation Body*. At the world level, the principal international forum is the International Laboratory Accreditation Cooperation – ILAC. In Serbia, accreditation is performed by the Accreditation Board of Serbia which is the successor of the former Accreditation Board of Serbia and Montenegro and which is the associate member of EA. The full membership in EA brings about the automatic membership in ILAC. The basic law in Serbia is the Law on Accreditation passed during the State Community Serbia and Montenegro.

Taking into account that accreditation is based and implemented pursuant to the harmonised international standards, and that there is a mutual recognition arrangement of accreditation bodies (either within regional accreditation organisations or between the accreditation bodies of

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two countries), accreditation is the only mechanism which ensures the *international recognition of competence* of the laboratories and other organisations for conformity assessment and, also the recognition of the certificates delivered by the accredited organisations.

The accreditation criteria for testing laboratories are regulated by the standard SCS ISO/IEC 17025:2006, the Law on Accreditation, and the conditions prescribed by the Accreditation Body of Serbia, as well as by other provisions and national and international standards and guidelines. The above Standard defines the requirements for the testing laboratory competence, disregarding the field of testing (biological, chemical, physical, mechanical, etc.).

The accreditation of the testing laboratory certifies that the laboratory is:

- competent for the specific testing, defined in the scope of accreditation (testing methods by the corresponding document on the specified subject of testing);
- that it complies with the provisions of the international standard SCS ISO/IEC 17025 which refer to *management system* and *technical requirements*; the management system should meet the requirements, it should be documented according to the standard and it should be fully in application;
- that it complies with the applicable terms of accreditation prescribed by the Accreditation Board of Serbia, the requirements of the national and international standards and guidelines, including those published by EA and ILAC, programmes/schemes of accreditation necessary for individual needs of the potential users of the testing laboratory services, as well as the legal and other regulations and commitments in the field of testing.

Accreditation procedure is carried out by the Accreditation Body. After the procedure, which is finalised by the *decision on accreditation*, in the case of the positive decision, the Accreditation Board of Serbia issues the *decision* and the *accreditation certificate* in two languages (in Serbian and in English).

The accreditation procedure consists of the following steps:

- Identification of the expressed intention
- Submission and analysis of application
- Preparation for assessment
- Assessment
- Reporting on assessment
- Decision-making on accreditation and delivery of decision
- Inspection and re-assessment.

2. IDENTIFICATION OF THE EXPRESSED INTENTION

First, the organisation sends a letter of intention to the Accreditation Body. Accreditation Body identifies that the organization wants to be accredited in certain accreditation scheme.

Organisation can send *the letter of intention* only after it has made the necessary preparations for accreditation. In the case of testing laboratory, this means that all the preparations have been undertaken, so that the laboratory complies with the international standard SCS ISO/IEC 17025:2006 and other requirements. In this aim, the testing laboratory for accreditation usually forms a project team consisting of the quality manager, chief of the laboratory and other relevant personnel (e.g. heads of the laboratory sections, testers, etc.).

The Accreditation Board of Serbia contacts the applicant, gives the explanations, and after the organisation has paid the necessary amount, it sends the set of documents in which the terms of accreditation are described, i.e.:

- Form of the terms of accreditation,
- list of standards and guidelines which should be met by the applicant,

- rules of accreditation including the accreditation costs,
- guidelines for the identification of the scope of accreditation.

3. SUBMISSION AND ANALYSIS OF THE APPLICATION FOR ACCREDITAION

The organisation submits the application for the testing laboratory accreditation and encloses the required documents. The application should be clearly defined and documented. In addition to the Form and the defined *fields of testing* and *scope of accreditation*, the documents should consist also of the *Annexes* among which are the complete *Rules on the quality* of the testing laboratory, *description of the personnel potentials* of the laboratory, the data on the *technical equipment of the* laboratory, etc.

Accreditation Body reviews the application form, surveys the enclosed documents and demands additional explanations, or possibly the additional documents, within a definite term. As a rule, the Accreditation Body always urges the applicant to perform the required activities within the limited time. Accreditation costs, which are paid by the applicant, are distributed by the phases and they mostly depend on the number of elements in the scope of accreditation and on the size of the team of assessors.

4. PREPARATION FOR ASSESSMENT

In this phase one of first steps is the appointment of the assessors' team leader by the Accreditation Body, and possibly other members of the team, to *check the documents* of the testing laboratory. Team leader assesses the documents to determine whether they are complete and in compliance with the conditions and the requirements for the testing laboratory accreditation. This refers primarily to the *Rules on the laboratory quality,* the *procedures* and *guidelines*.

If the objective assessment requires additional documents, the team leader informs the responsible officer in charge in the Accreditation Body and asks for the documents to be delivered, gets in touch with the organisation and solves the uncertainties or notes down the need for additional explanations. These activities can be realised during the pre-assessment visit.

The non-conformities assessed by the team leader should be eliminated before the pre-assessment visit. The *objective proof* for it is the report by the applicant on the performed *internal checking* of the laboratory. If the applicant does not send the report within the time limit, the accreditation procedure can be stopped. The *pre-assessment visit* is organised if the conclusion by the team leader is positive, which means that the documents comply with the requirements and that the non-conformity is eliminated.

The pre-assessment visit enables the direct survey of the organisation, location and resources of the applicant. It verifies that the non-conformity is eliminated and additionally checks the conformity with the general conditions and requirements and determines all the essential elements for the drawing up of the assessment plan. The report on the pre-assessment visit, which is sent to the Accreditation Body by the team leader, can have two proposals: to undertake the assessment or to terminate the accreditation procedure.

If the conclusion of the team leader is positive, the Accreditation Body completes the team of assessors with technical evaluators and possibly technical experts, i.e. the professionals for the methods from the defined scope of the laboratory accreditation. Parallel with the final appointment of the team members, the team leader formulates the detailed plan of assessment and the working documents.

5. ASSESSMENT

After the applicant organisation, which is in the procedure of testing laboratory accreditation, agrees with the plan of assessment and after the objective proof that all the previous non-conformities are eliminated, which is proved by the team leader, the team starts the assessment in the premises where the conformity is assessed. The assessment proceeds in phases. The main phases are: introductory meeting, on-site checking and assessment, final meeting, and the report on assessment and implementation and monitoring of the *correction measures*.

The checking and assessment includes both the analysis and the assessment of the found condition, and the report during the checking. The analysis of results is aimed at the systematisation of data on the assessed condition. The assessors make assessment of the aspects of the conformity with the applicable requirements. The existing non-conformities are classified in two categories: minor and major.

The final meeting consists of:

- review and explanation of the findings,
- conclusion of the team on the conformity,
- obligations of the laboratory regarding the non-conformity and time limits for the correction measures,
- the assessed laboratory can give its opinion on the report and the measures for the elimination of the non-conformities within the time limit,
- further activities and the conditions for the continuation of the accreditation.

The minutes are signed by the team leader and the team members, and by the authorised person in the applicant organisation.

6. REPORTING ON ASSESSMENT

The team of assessors prepares and delivers to the Accreditation Body the report on assessment with the opinion on accreditation. They enclose: the report on non-conformity, the minutes from the final meeting and the findings by the assessors. The Accreditation Body mails the report on assessment to the applicant, whose laboratory is assessed, pointing out the raised non-conformities and the period for settlement of non-conformities.

Based on the report of the team of assessors, the Accreditation Body can grant the accreditation, refuse the accreditation with the repetition of the procedure or postpone the decision (within the time limit) until the non-conformity is eliminated.

The monitoring and implementation of correction measures can be done in two ways. The first method includes the analysis (by the team of assessors) of the plan of correction measures created by the laboratory, potential visit to the laboratory by the team, and the analysis of the report on internal checking, and the distribution of the report on assessment. The second method includes a partial additional on-site assessment.

7. DECISION MAKING ON ACCREDITATION AND THE DELIVERY OF THE CERTIFICATE

After the team's proposal is received, the Accreditation Body undertakes the preparation for the decision making on accreditation. The decision can be:

- accreditation is granted
- decision is postponed (within the time limit)
- accreditation is not granted.

If the decision is positive, the written decision and accreditation certificate in Serbian and English are delivered to the applicant for testing laboratory accreditation. The decision and the certificate are valid for four years.

8. SUPERVISION AND RE-ASSESSMENT

If the accreditation is granted, the Accreditation Body monitors whether the accredited organization complies with the applicable criteria. Regular supervision is once a year. Additionally, the Accreditation Body can undertake, if necessary, an extraordinary supervision: if there are remark or written complaints Accreditation Body by the stakeholders (e.g. clients, state organs, etc.), or if the laboratory sends an information on the changes of conditions. After the expiration of the certificate (four years) JUAT assesses accredited organization again.

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ASPECTS OF INTELLECTUAL PROPERTY PROTECTION IN FORESTRY

Małgorzata GAJOS[1]

Abstract: *Forestry as an art, science, and practice of studying and managing forests, plantations, and related natural resources, creating objects which could be subjects of intellectual property protection. The notion of intellectual property according to legal regulations and literature may be defined sensu stricto and sensu largo. In sensu stricto definition describes it as a complex of authorisations including of copyright. In sensu largo definition it covers laws referring to literary, artistic and scientific works (copyrights), as well as the laws concerning the industrial property (understood as a complex of subjective rights, the object of which are example the following non-material goods: inventions, industrial designs, trademarks and service marks, geographical indications, as well as the rights defined in regulations concerning repression of unfair competition). The object of the copyright protection are works. From the point of view of the law a work can also be a computer programme and a database. The paper describes mainly the legal protection of databases, but also aspects of legal protection of intellectual property in forestry sensu largo.*

Key words: forestry, intellectual property, database legal protection

1. INTRODUCTION

Forestry is the art, science, and practice of studying and managing forests and plantations, and related natural resources. Silviculture, a related science, involves the growing and tending of trees and forests. Modern forestry generally concerns itself with assisting forests to provide timber as raw material for wood products; wildlife habitat; natural water quality regulation; recreation; landscape and community protection; employment; aesthetically appealing landscapes; and a 'sink' for atmospheric carbon dioxide. Forests have come to be seen as one of the most important components of the biosphere, and forestry has emerged as a vital field of science, applied art, and technology [11]. Forestry as a complex of forest sciences consist of the following issues: forest breeding, protection of forest, use of forest, arrange of forest and hunting economy [12]. Forestry creating objects which could be subjects of intellectual property protection.

The legal concept of intellectual property and literature may be defined *sensu stricto* and *sensu largo* [8]. The *sensu stricto* definition describes it as a complex of authorisations including copyright as well as so-called neighbouring rights. The *sensu largo* definition was included in the convention establishing the World Intellectual Property Organisation (WIPO) [2] and covers laws referring to literary, artistic and scientific works (copyright), as well as laws concerning industrial property (as a complex of subjective rights, the object of which are the following non-material goods: inventions, utility models, industrial designs, trademarks and service marks, geographical indications, topographies of an integrated circuit, as well as the rights defined in regulations concerning repression of unfair competition). Aspects of legal protection, presented in this paper will refer to *sensu largo* intellectual property, on the base

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on general rules contained in international conventions, treaties[2] [1, 10, 13] and European directives [4, 5, 6]. Legal regulations relating to intellectual property in forestry are applied in the same way as rules in other fields. Special intellectual property regulations concerning only forestry do not exist.

The question of intellectual property protection in forestry, as a scientific-technical discipline, may be considered from many aspects: copyright protection, *sui generis* protection as well as the industrial property protection. The paper describes mainly the legal protection of databases. According to the art. 1 paragraph 2 Directive on the legal protection of databases [6], database it is a collection of independent works, data or other materials arranged in a systematic or methodical way and individually accessible by electronic or other means.

2. COPYRIGHT PROTECTION

The subject of copyright protection are works produced by the creative activity of an individual person, in any form, independent of values, destination and mode of expression. Deciding, however, whether a given study has the attributes of creative activity of an individual isn't easy. Recently qualifying the creative process is connected with technical progress, i.e. that the tools used in the creative process change. Doubtless the phenomenon of fast technical progress and computerisation of the means of expression now appears in forestry. An example of a work in forestry may be a map (e.g. Forest Fire Danger Map) or a picture. In law a work can also be a computer programme or a database. Many computer programmes exist, created for the needs of forestry especially within the range of Geographic Information System (GIS). Valid rules for their protection are the same as for all other computer programmes and they are defined in law, e.g. Directive on the legal protection of computer programs [5]. A database, the source of information often created and used in forestry (forest monitoring database, database of seed plantation), can be together with copyright protection an object of the *sui generis* right [6, 3].

In accordance with Directive on the legal protection of databases, databases which, by reason of the selection or arrangement of their contents, constitute the author's own intellectual creation shall be protected as such by copyright. No other criteria shall be applied to determine their eligibility for that protection (art. 3 paragraph 1 Directive).

The author of a database shall be the natural person or group of natural persons who created the base or, where the legislation of the Member States so permits, the legal person designated as the rightholder by that legislation (art. 4 paragraph 1 Directive).

In respect of the expression of the database which is protectable by copyright, the author of a database shall have the exclusive right to carry out or to authorise (art. 5 Directive):

- temporary or permanent reproduction by any means and in any form, in whole or in part;
- translation, adaptation, arrangement and any other alteration;
- any form of distribution to the public of the database or of copies thereof. The first sale in the Community of a copy of the database by the rightholder or with his consent shall exhaust the right to control resale of that copy within the Community;
- any communication, display or performance to the public.

2 After Montenegro's separation from Serbia in June 2006, the Republic of Serbia continues the state and legal identity of the state union of Serbia and Montenegro. Therefore, the Republic of Serbia will continue to exercise its rights and to honour its commitments deriving from treaties administered by WIPO (Declaration by the Republic of Serbia; October 12, 2006; http://www.petosevic.com/resources/news/2006/10/000071). Madrid Filing Fee Calculator designated Serbia and Montenegro with the code YU. The new code is RS and it stands for Republic of Serbia (Madrid Filing Fee Calculator – WIPO's New Code for Serbia is RS; October 30, 2006; http://www.petosevic.com/resources/news/2006/10/000072).

The performance by the lawful user of a database or of a copy thereof of any of the acts listed above which is necessary for the purposes of access to the contents of the databases and normal use of the contents by the lawful user shall not require the authorisation of the author of the database. Where the lawful user is authorised to use only part of the database, this provision shall apply only to that part (art. 6 paragraph 1 Directive). Member States shall have the option of providing for limitations on the rights in the following cases (art. 6 paragraph 2 Directive):

- in the case of reproduction for private purposes of a non-electronic database;
- where there is use for the sole purpose of illustration for teaching or scientific research, as long as the source is indicated and to the extent justified by the non-commercial purpose to be achieved;
- where there is use for the purposes of public security of for the purposes of an administrative or judicial procedure.

3. SUI GENERIS PROTECTION

Sui generis protection of databases was inaugurated by a Directive of the European Parliament and Council from 1996 dealing with legal protection of databases [6]. The necessity of assuring the protection of databases for their producers became the reason for the introduction of this regulation [7]. The *sui generis* right lets the producer of the database forbid illegal data taking and/or the reusing the whole or part of the database as preparation of the database requires qualitative and/or quantitative preparation on the part of the compiler and verification or gathering of its content (art. 1 paragraph 2 Directive). The content of this law, in spite of both its positive and negative results, met with acceptance among database producers.

Extraction means the permanent or temporary transfer of all or a substantial part of the contents of a database to another medium by any means or in any form. Re-utilisation means any form of making available to the public all or a substantial part of the contents of a database by the distribution of copies, by renting, by on-line or other forms of transmission. The first sale of a copy of a database within the Community by the rightholder or with his consent shall exhaust the right to control resale of that copy within the Community. Public lending is not an act of extraction or re-utilisation (art. 7 paragraph 2 Directive).

The maker of a database which is made available to the public in whatever manner may not prevent a lawful user of the database from extracting and/or re-utilising insubstantial parts of its contents, evaluated qualitatively and/or quantitatively, for any purposes whatsoever. Where the lawful user is authorised to extract and/or re-utilise only part of the database, this paragraph shall apply only to that part. He also may not perform acts which conflict with normal exploitation of the database or unreasonably prejudice the legitimate interests of the maker of the database and may not cause prejudice to the holder of a copyright or related right in respect of the works or subject matter contained in the database (art. 8 paragraph 1 - 3 Directive).

Member States may stipulate that lawful users of a database which is made available to the public in whatever manner may, without the authorisation of its maker, extract or re-utilise a substantial part of its contents (art. 9 Directive):

- in the case of extraction for private purposes of the contents of a non-electronic database;
- in the case of extraction for the purposes of illustration for teaching or scientific research, as long as the source is indicated and to the extent justified by the non-commercial purpose to be achieved;
- in the case of extraction and/or re-utilisation for the purposes of public security or an administrative or judicial procedure.

Term of protection for database runs from the date of completion of the making of the database. It shall expire fifteen years from the first of January of the year following the date of completion. In the case of a database which is made available to the public in whatever manner before expiry of the period provided for in paragraph 1, the term of protection by that right shall expire fifteen years from the first of January of the year following the date when the database was first made available to the public. Any substantial change, evaluated qualitatively or quantitatively, to the contents of a database, including any substantial change resulting from the accumulation of successive additions, deletions or alterations, which would result in the database being considered to be a substantial new investment, evaluated qualitatively or quantitatively, shall qualify the database resulting from that investment for its own term of protection (art. 10 paragraph 1 – 3 Directive).

The protection under the *sui generis* right shall apply to database whose makers or rightholders are nationals of a Member State or who have their habitual residence in the territory of the Community (art. 11 paragraph 1 Directive). Shall also apply to companies and firms formed in accordance with the law of a Member State and having their registered office, central administration or principal place of business within the Community; however, where such a company or firm has only its registered office in the territory of the Community, its operations must be genuinely linked on an ongoing basis with the economy of a Member State (art. 11 paragraph 2 Directive).

4. INDUSTRIAL PROPERTY PROTECTION

Industrial property protection covers, in relation to forestry, patent protection (patents for the invention and protective rights for a utility model), protection of trademarks as well as repression of unfair competition. The devices for forestry research (e.g. machine to plant), may be patented if they meet the requirements of patentability. Forest products can be protected by trademark services connected with the distribution of these products by the service mark. However, acts are against the law or morality if they endanger or infringe the business of other businesspeople or customers and may be treated as acts of unfair competition. In the field of forestry such a deed may be e.g. the situation in which a someone offers elements of a map, of which they are neither the manufacturer nor owner.

5. CONCLUSIONS

Intellectual property law it is a law for among others the environment, for national development, for consumer protection, for forestry, for tourism, for agriculture, for education, and many more. It would supporting individual creativity and stating the desirability of a flowering of creativity, since innovation contributes to society's development.

From the subject of intellectual property protection, in forestry databases protection it seems to be one of the important problem. No business or organisation can afford to ignore the issue of databases protection.

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SECTION 6

RELIABILITY OF RESULTS OF BEECH HIGH STAND INVENTORY BY SAMPLE METHOD

Miloš KOPRIVICA[1]

Abstract: *The variation and precision (reliability) of estimate of taxation elements in beech high stands was researched by the sample method. Five characteristic stands were selected based on their diameter and height structure, as well as their spatial variation. They are uneven aged beech stands, with a slight percentage of other tree species. The stand inventory consists of a systematic distribution of sample plots sized 500 m². The sample size is 10–29 sample plots, and the attained precision of estimate (probability 95%) is from ±12% to ±23%. The coefficient of variation of stand volume is 27%–49%. Average coefficient of variation is about 35%, and double relative error (for the sample of 20 sample plots) is ±16.0%. Altogether 100 sample plots, i.e. 1327 trees were measured (diameter above 10 cm).*

Key words: sample, beech, stand, forest inventory, variation, precision, accuracy, reliability.

1. INTRODUCTION

Stand inventory can be done in several ways: by the complete mensuration, partial mensuration, ocular estimate and by modern remote detection methods. Still, the sample method, i.e. partial measurement based on statistical methods is the most frequently applied method. Sample planning in forest inventory is a complex problem requiring previous answers to many questions. The study of the variation of the most significant taxation elements (number of trees, basal area, volume and volume increment) and predicting the precision, i.e. accuracy, of their estimate is especially significant. The difference between the terms precision and accuracy has already been dealt with (Koprivica, 2004).

In the statistical sense, a stand represents a set of trees of a given tree species. However, for practical reasons in forest stand inventory, it is defined as a set of sample plots of a given form and size, i.e. as a set of taxation element values on the sample plots. The sample plot form and size affect significantly the variation of taxation elements, and their number in the sample affects the precision of the estimate. The accuracy of the estimate of the size of taxation elements per hectare and on the entire area of the stand, or a larger inventory unit, is the data we are most interested in and, along with precision, it also contains a component of partiality. Partiality is the consequence of the presence measurement errors (rough, systematic and random). The effect of measurement errors on the accuracy of estimate of taxation elements of the inventory unit is more or less known in dendrometry, i.e. forest inventory, and there is no need of repeating it. Instead, we shall remind ourselves of the fact that we can have a precise but inaccurate inventory, if e.g. basal area or volume contain a great systematic error. Therefore we try to make forest inventory as accurate as possible, with the maximum precision, i.e. that it has the least possible error of the sample with the minimal systematic error, or without it (Pranjić, A., 1987).

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2. TASK AND OBJECTIVE

Starting from the known fact that each narrow or wide category of forest, i.e. stand, is characterised by the spatial variation of the values of taxation elements, this study has the following tasks of research:

- Determine the variation and the precision of estimate of the most significant taxation elements in beech high stands on individual localities in East and West Serbia;
- Plan the necessary size of the sample for beech high stand inventory, depending on the range of taxation element variation and the necessary precision, i.e. reliability (probability) of estimate.

The solution of the assigned tasks defines the objective of the research – the creation of the professional base for the reliable inventory of beech high forests in Serbia.

3. STUDY AREA AND METHOD

The research was carried out in five beech high stands in East and West Serbia, which are characterised by different site and stand characteristics. They are classified as beech submontane forest (*Fagetum moesiacae submontanum*) and beech montane forest (*Fagetum moesiacae montanum*), altitude 500 - 1000 metres on different bedrocks and soil types. Slope is on average 10–25°. Their structure is group-selection all-aged stands in which tree-selection and group-selection felling systems were applied.

For this research, the stand characteristics are more significant than site characteristics, i.e. the stand characteristics most often reflect the site characteristics, because these are natural forests of beech in which management measures were performed in harmony with the well-defined technical aims.

Stand area varies from 12 to 29 ha, site class from I/II to III/IV, canopy from 84 to 90%, mean diameter 30 - 37 cm, mean height 18 - 28 m, and they are pure beech stands. The number of trees per hectare (above 10 cm diameter at breast height) varies from 214 to 321, basal area 23 - 33 m^2/ha, volume 333 - 522 m^3/ha, volume increment 5.0 - 10.5 m^3/ha.

The tree volume and volume increment were calculated by regression equations (Koprivica, Matović, 2005) obtained based on tariffs for beech in Serbia (Mirković 1959, after Nikolić, Banković, 1992).

The size, variation, and precision of estimate of the stand taxation elements were determined by the method of simple (systematic) samples. The applied simple sample plots are circular, sized 500 m^2 (radius 12.62 m), distributed in the stand in the grid network, spacing 100 metres (one circle represents one hectare). The size of the samples depended exclusively on the stand area and ranged from 10 to 29 sample plots. The intensity of measurement was 5% of the stand area.

The diameters, heights and diameter increments of all trees above the taxation limit (10 cm) were measured on all sample plots in the stand. The number of taxation elements covered by the collection of field data for the project "Method of assessment of quality and assortment structure of beech high stands in Serbia" is much higher and it is described in detail in the method of field data collection and processing (Koprivica *et al.*, 2005).

The data are processed by the specially elaborated method for this purpose. The specificity of data processing method is that a specially determined tariff series is made for each sample plot, based on the height of the trees with diameter at breast height 30–70 cm. The standard site-quality series of beech heights in Serbia is applied (Mirković, 1959, after Nikolić, Banković, 1992).

After the tariff series is determined, volume and volume increment are calculated for each tree, corresponding to one centimetre of diameter increment and height increment. Volume increment is obtained by multiplying the obtained value with the real diameter increment. The data on tree volume and volume increment are converted individually to hectare and summed.

The obtained data on the values of taxation elements on sample plots (reduced to hectare) are processed by statistical methods: descriptive statistics and statistics of simple random sample.

4. RESULTS

The study results are presented in the Tables for the study stands, i.e. the sample plots. The following taxation elements are observed on sample plots: mean diameter, mean height, tariff series, tree number, basal area, stand volume and volume increment per hectare. The analysis covers the present state of the stand. The following statistical values are given for sample plots as

the sample elements: number of sample elements (n), arithmetic mean ($\overline{X}$), minimal (X_{min}) and maximal (X_{max}) value, standard deviation (S_x), variation coefficient (CV%), relative standard error (m_x%), coefficient of skewness (α_3) and coefficient of kurtosis (α_4).

The theoretical base of the sample method, with the implementation in forest inventory, is reported by Koprivica (1984).

Aiming at a better survey, the study results are first presented separately for each stand and then the results are synthesised.

4.1 Beech high stand 33a

This stand is situated in the Severni Kučaj forest area, Management Unit "Majdan – Kučajna". Altitude is about 500 m, exposure northeast, slope 15–35°. Parent rock consists of deep limestones, the soil is dystric brown (acid brown) soil, depth 40–80 cm. Canopy is 0.9, principal tree species is beech. Stand area is 22.7 ha, site class II.

The parameters of the values, variation, and precision of estimate of the stand taxation elements are presented in Table 1.

Table 1. Stand 33a – sample plot statistics

Taxation element	n	$\overline{x}$	Xmin	Xmax	Sx	CV%	mx%	α3	α 4
Mean diameter	23	37.0	25.5	56.31	7.81	21.12	4.40	0.67	3.08
Mean height	23	27.5	22.2	33.8	3.04	11.04	2.30	0.58	2.87
Tariff series	23	2.73	1.0	5.0	1.18	42.94	8.95	0.37	2.43
Tree number	23	275.6	80.0	460.0	108.2	39.25	8.18	0.23	2.20
Basal area	23	33.42	16.68	47.14	9.20	27.54	5.74	–0.06	1.88
Volume	23	522.52	298.68	875.00	163.57	31.30	6.53	0.54	2.55
Volume increment	23	8.60	2.11	14.41	2.52	29.33	6.12	–0.04	4.57

The coefficient of variation is the most significant element for the analysis of variation of taxation elements, and relative standard error - for the analysis of the precision of estimate. As these parameters are given in percentage, the variation and precision of estimate of taxation elements can be compared in the same stand and in different stands.

Table 1 shows that the most variable of the study stand taxation elements are tariff series (CV ≈ 43%) and tree number per hectare (CV ≈ 39%). Still, the volume variation, which is not high (CV ≈ 31%), is the most significant. Somewhat less variable are volume increment and basal area. Variation of basal area is about 88% of the volume variation, and it is more easily determined in practice. It is characteristic that the variations of mean height and mean diameter on sample plots are low.

In the sample of 23 sample plots, circular, area 500 m^2, the error of the estimate (probability 95% and degree of freedom 22; t = 2.074) is: for tree number ±17.0%, basal area ±11.9%, volume ±13.5% and volume increment ±12.7%, per hectare.

The reliability of the identified taxation elements on the entire stand area will be the same as per hectare, if the area is accurate. In the opposite, the error of the stand area should be taken into account.

4.2 Beech high stand 42a

This stand is situated in the Severni Kučaj forest area, Management Unit "Crni Vrh". Altitude is about 950 m, exposure Northwest, slope 10–15°. Parent rock consists of andesites, soil is dystric brown (acid brown) soil, depth 40–80 cm. Canopy is about 0.9, principal tree species is beech. The stand is group-selection all-aged stand, area 17.5 ha, site class III.

The data on the values, variation, and precision of estimate of the stand taxation elements are presented in Table 2.

Table 2. Stand 42a – sample plot statistics

Taxation element	n	$\bar{x}$	Xmin	Xmax	Sx	CV%	mx%	α3	α 4
Mean diameter	18	33.94	21.12	45.95	5.78	17.02	4.01	0.18	3.85
Mean height	18	21.64	16.18	26.31	2.90	13.38	3.15	−0.13	2.31
Tariff series	18	4.89	4.0	6.0	0.68	13.84	3.26	0.13	2.47
Tree number	18	321.1	160.0	520.0	115.09	35.84	8.45	0.30	1.90
Basal area	18	31.67	18.29	43.05	7.33	23.13	5.45	−0.22	2.14
Volume	18	379.57	215.07	563.15	88.51	23.32	5.50	0.11	2.86
Volume increment	18	6.61	4.27	11.02	1.73	26.27	6.19	1.11	3.91

Table 2 shows that the most variable of the stand taxation elements is tree number (CV ≈ 36%). Variation coefficients of volume and basal area are almost equal (CV ≈ 23%), which points to a high stand homogeneity. The stand is homogeneous also regarding the variation of its tariff series (CV ≈ 14%).

In the sample of 18 sample plots (probability 95% and degree of freedom 17; t = 2.110), the error of the estimate is: for tree number ±17.8%, basal area ±11.5%, volume ±11,6% and volume increment ±13,1%, per hectare and on total stand area (if the area is determine sufficiently accurately).

4.3 Beech high stand 42b

This stand is in the same compartment as the stand 42a, only at the higher altitude (about 1000 m). Other site characteristics are similar, but its stem quality is much lower. Stand area is 12.0 ha, site class III/IV.

The data on variation and precision of estimate of stand taxation elements are presented in Table 3.

Table 3. Stand 42b –sample plot statistics

Taxation element	n	$\bar{x}$	Xmin	Xmax	Sx	CV%	mx%	α3	α 4
Mean diameter	10	33.17	20.73	45.48	6.73	20.28	6.41	−0.140	3.95
Mean height	10	18.29	13.26	22.41	2.56	13.97	4.42	−0.611	3.88
Tariff series	10	6.30	6.00	7.00	0.48	7.67	2.43	1.035	1.78
Tree number	10	308.0	200.0	440.0	69.41	22.54	7.13	0.257	3.28
Basal area	10	31.53	19.19	40.22	6.45	20.45	6.47	−0.475	3.25
Volume	10	333.22	146.62	441.83	90.18	27.06	8.56	−0.749	3.77
Volume increment	10	4.96	3.40	7.35	1.04	21.05	6.66	1.202	5.94

Table 3 shows that the variation of the tariff series (CV ≈ 8%) is exceptionally low, followed by mean height (CV ≈ 14%), mean diameter (CV ≈ 20%) and other taxation elements. Volume (CV ≈ 27%) has the highest variation.

In the sample of 10 sample plots (probability 95% and degree of freedom 9; t = 2.262), the error of the estimate is: for tree number ±16.1%, basal area ±14.6%, volume ±19,4% and volume increment ±15,1%, per hectare.

Although stands 42a and 42b belong to the same compartment, they are very much different because of the stand conditions, which is reflected on the variation of their taxation elements and on the precision of estimate.

4.4 Beech high stand 122a

This stand is situated in Podrinjsko-Kolubarski forest area, in Management Unit "Istočna Boranja". Altitude is about 800 m, exposure Northwest, slope 5–30°. Bedrock is granodiorite, soil eutric brown or brown forest soil, depth 80–120 cm. Canopy is about 0.9, principal tree species is beech. This is a pure beech group-selection all-aged stand, area 29.0 ha, site class I/II. The stand is exceptionally good quality, but it is inadequately regenerated.

The data on variation and precision of estimate of stand taxation elements are presented in Table 4.

Table 4. Stand 122a – sample plot statistics

Taxation element	n	$\overline{x}$	Xmin	Xmax	Sx	CV%	mx%	α3	α 4
Mean diameter	29	39.38	19.20	54.21	8.91	22.63	5.39	–0.10	2.46
Mean height	29	29.00	18.33	39.36	4.69	16.17	3.00	–0.04	3.38
Tariff series	29	1.79	1.00	3.00	0.73	40.49	7.52	0.34	1.95
Tree number	29	213.79	100.00	400.00	85.04	39.78	7.39	0.78	3.00
Basal area	29	29.03	17.94	51.83	9.31	32.05	5.95	0.75	2.90
Volume	29	503.68	246.49	972.84	185.53	36.83	6.84	0.86	3.12
Volume increment	29	10.50	5.42	16.51	2.66	25.38	4.71	0.10	2.62

Table 4 shows that in this stand the least variable elements are mean height (CV ≈ 16%) and mean diameter (CV ≈ 23%). It is characteristic that the tariff series (site class) variation is similar to the variation in stand 33a (CV ≈ 40%), in contrast to stands 42a and 42b, where the variation coefficient is 10–15%. These data indicate the spatial heterogeneity, i.e. homogeneous site classes.

Tree number varies maximally (CV ≈ 40%), and then volume (CV ≈ 37%). Variation coefficient of basal area is 32% and accounts for 87% of the volume variation coefficient. It is interesting that volume increment has the lowest variation (CV ≈ 25%).

In the sample of 29 sample plots (probability 95% and degree of freedom 28; t = 2.048), the error of the estimate is: for tree number ±15.3.1%, basal area ±12.2%, volume ±14,0% and volume increment ±9,6%, per hectare.

The reliability of estimate does not ensure the safe planning at the stand level. For example, if for stand volume the required reliability of estimate is ±10%, the number of established sample plots in the stand should be 57, in stead of 29 sample plots. The increase of the sample is 1.96 times, and the decrease of error is 1.4 times ($1.4^2 = 1.96$). The distance between the centres of the sample plots would be 71.3 m, and not 100 m. Practically, in this case, one sample plot represents 0.5 ha, an the intensity of measurement accounts for 10%.

4.5 Beech high stand 27a

This stand is also in Podrinjsko-Kolubarski forest area, but in Management Unit "Zapadna Boranja". Altitude is about 550 m, exposure West, slope 10–35°. Parent rock consists of schists and sandstones, soil is dystric brown or acid brown soil, depth 40–80 cm. Canopy is about 0.8, principal tree species is beech. It is a pure beech stand of group-selection all-aged structure. Stand area is 18.2 ha, site class III.

Data on variation and precision of estimate of stand taxation elements are presented in Table 5.

Table 5. Stand 27 – sample plot statistics

Taxation element	n	$\overline{x}$	Xmin	Xmax	Sx	CV%	mx%	α3	α 4
Mean diameter	20	30.7	18.3	46.7	7.24	23.63	5.28	0.46	2.63
Mean height	20	23.9	18.7	33.9	4.29	17.95	4.01	0.89	3.05
Tariff series	20	2.75	1.0	4.0	0.85	30.93	6.92	−0.60	3.24
Tree number	20	259.0	140.0	400.0	72.68	28.06	6.27	−0.04	2.56
Basal area	20	23.07	10.87	43.01	8.85	38.34	8.57	0.71	3.03
Volume	20	350.38	110.09	759.13	170.83	48.76	10.90	0.78	3.20
Volume increment	20	7.92	4.81	11.69	2.08	26.22	5.86	−0.22	1.98

Table 5 shows that in this stand the least variable element is mean height (CV ≈ 18%), and then mean diameter (CV ≈ 24%). Variation coefficient of the tariff series, i.e. site class is 30.9%. Volume (CV ≈ 49%) has the highest variation and volume increment - considerably lower (CV ≈ 26%). Variation coefficient of the basal area is about 38% and accounts for 78.6% of the volume variation coefficient, which is the lowest value in the study analyses so far.

In the sample of 20 sample plots (probability 95% and degree of freedom 19; t = 2.090), the error of the estimate is: for tree number ±13.1.1%, basal area ±17.9%, volume ±22.8% and volume increment ±12.2%, per hectare.

It is evident that there are great sample errors in the estimated values of taxation elements, particularly the volume. To decrease the error volume to ±10%, the number of established sample plots in the stand should be 104, instead of 20 sample plots. The increase of the sample is 5.20 times, and the decrease of error is 2.28 times ($2.28^2 = 5.20$). The distance between the centres of the sample plots would be 43.7 m, and not 100 m. One circle would represent 0.19 hectares. Clearly, this increase of the sample size is not economically justified, and the planning at the stand level would be unreliable.

5. DISCUSSION

Chapter 4 presents the analysis of variation and precision (accuracy) of estimate of stand taxation elements. The five analysed stands differ significantly in variation, i.e. in the attained precision of estimate of taxation elements.

To obtain a better insight in the variation and the precision of estimate of the stand taxation elements, Tables 6.1 and 6.2 present the variation coefficients and the relative standard errors of the sample, under probability 95% and the appropriate degree of freedom.

Table 6.1 shows the following: variation coefficient of stand mean height (per sample plots) is 11–18%, mean diameter 17–24%, tariff series (site class) 8–43%, tree number 22–40%, basal area 20–38%, volume increment 21–30% and volume 23–49%. The values of variation are not high, primarily because of the relatively sufficient sample area (500 m^2). If sample plots had been smaller, the values of variation coefficients would have been higher and vice versa – the larger sample plots result in the lower value of variation coefficients.

Table 6.1. Variation coefficient of taxation elements of beech stands

No	Stand	Number of circles	Variation coefficient (%)						
			$\bar{d}$	$\bar{h}$	$\bar{t}_n$	N	G	V	Iv
1.	33a	23	21.1	11.0	42.9	39.3	27.5	31.3	29.3
2.	42a	18	17.0	13.4	13.8	35.8	23.1	23.3	26.3
3.	42b	10	20.3	14.0	7.7	22.5	20.5	27.1	21.1
4.	122a	29	22.6	16.2	40.5	39.8	32.1	36.8	25.4
5.	27a	20	23.6	17.9	30.9	28.1	38.3	48.8	26.2
Average[2]		20	20.9	14.5	25.7	32.7	27.7	33.4	26.0

Table 6.2. Error of estimate of beech stand taxation elements

No.	Stand	Number of circles	Error of the estimate (%)						
			$\bar{d}$	$\bar{h}$	$\bar{t}_n$	N	G	V	Iv
1.	33a	23	9.13	4.77	18.56	16.97	11.90	13.54	12.69
2.	42a	18	8.47	6.65	6.88	17.84	11.50	11.61	13.07
3.	42b	10	14.50	10.00	5.50	16.13	14.64	19.36	15.06
4.	122a	29	11.04	6.14	15.40	15.13	12.19	14.01	9.65
5.	27a	20	11.04	8.38	14.46	13.10	17.91	22.78	12.25
Average		20	10.48	6.75	12.01	15.74	13.39	15.76	12.03

Relative errors of sample (probability 95% and appropriate degree of freedom) in the study stands range in the following intervals (Table 6.2): mean height ±4.8% - ±10.0%, mean diameter ±8.5% - ±14.5%, tariff series (site class) ±5.5% - ±18.6%, tree number ±13.1% - ±17.8%, basal area ±11.5% - ±17.9%, volume increment ±9.6% - ±15.1% and volume ±11.6% - ±22.8%. In addition to the spatial variation of the stand taxation elements, the sample size (number of established sample plots in the stand) has the decisive significance for the precision of estimate.

Table 7 presents the average values of variation coefficients and relative errors of the sample[3].

The presented data approximately correspond to the sample of 20 sample plots, i.e. the stand area of 20 hectares, with the average value of taxation elements of all the study stands.

Table 7. Average values of variation coefficients and relative errors

Taxation element	Variation coefficient (%)	Relative error of the sample (± %)
Mean height	14.5	6.75
Mean diameter	20.9	10.48
Tariff series (site lass)	25.7	12.01
Volume increment	26.0	12.03
Basal area	27.7	13.39
Tree number	32.7	15.74
Volume	33.4	15.76

If the lowest variation coefficient (mean height) is taken as the base of the indexes of variation coefficients of stand taxation elements, the following indexes are obtained: mean diameter 1.4, tariff series 1.8, volume increment 1.8, basal area 1.9, tree number 2.3 and volume also 2.3.

2 In Tables 6.1 and 6.2, the averages are obtained as the weighted values: the average value of taxation elements is taken as the weight for variation coefficients, and the numbers of sample plots in the stands - for the error of the estimate.

3 Double relative error of taxation elements, which represents the error of estimate by sample, is usually applied in forest inventory. However, this is theoretically correct only in the case of the sample size of 60 elements (sample plots) and under probability 95%.

However, for practical reasons, the variation coefficient of basal area should be taken as the base. In this case, the following indexes of variation are obtained: mean height 0.5, mean diameter 0.8, tariff series 0.9, volume increment 0.9, tree number 1.2 and volume 1.2.

The sample of the number of sample plots established in the study stands was 10 – 29. The obtained relative errors of samples for the most significant taxation elements (tree number, basal area, volume increment and volume) of the stand per hectare were ±12% - ±16%. However, in forest inventory for attaining the desired accuracy of estimate, the variation coefficient of volume is used in planning the necessary size sample.

Table 6.2 presents the data on the precision of estimate of the volume in beech stands, under sample intensity 5.0% and the distance between sample plots (circles) in the grid network 100×100 m. Sample size depended exclusively on the stand area, and the precision of estimate (relative error at P = 95%) depended on the variation of volume in the stand (variation coefficient) and on the size of the sample (number of established sample plots – size 500 m^2). The attained precision of estimate of the volume is from ±11.6% to ±22.8%, i.e. for the average stand size of ±15.8%, it is not sufficient for the reliable management planning at the stand level.

In the majority of European countries, the required precision of volume estimate in high all-aged stands amounts to ±10.0%, and in Serbia ±8.0%. The necessary number of sample plots in the sample (n) is planned for the permitted relative errors of sample, the distance between sample plots (circles) in the grid network (x) and the intensity of the sample (p) in percents (Table 8). To achieve the required precision of estimate in the former case (±10.0%) for the average stand size, the sample size and intensity should be increased by 2,25 times, and the distance should be decreased by 1.5 times. In the latter case (±8.0%), the sample size and intensity should be increased by 3.50 times, and the distance should be decreased by 1.88 times. In the former case, one sample plot represents the area of 0.442 ha, and in the latter case it is 0.284 ha. The sample intensity per stands in the former case varies from 6.28 to 26.14%, and in the latter case, from 9.7 to 41.0%.

To be sure, volume variation coefficient should be 35% and the value of the sample with error should be ±10%. Under this assumption of variation coefficient and relative error of volume, the number of sample plots which should be established in the stand (irrespective of the size) should be 49 (approximately 50). For the stand area of 25 ha, the intensity of measurement accounts for 10%, for the smaller stand, the intensity will be higher, and for the stand of the larger area, the intensity will be lower.

Table 8. Necessary sample size for the required precision of volume estimate in beech high stands

Stand	Area	Variation coefficient (%)	Elements for the necessary precision of estimate					
			±10%			±8%		
			n	x	p	n	x	p
33a	22.70	31.3	39	76.3	8.6	61	61.0	13.4
42a	17.52	23.3	22	89.2	6.3	34	71.8	9.7
42b	11.97	27.1	29	64.3	12.1	46	51.0	19.2
122a	29.05	36.8	54	73.3	9.3	85	58.5	14.6
27a	18.17	48.8	95	43.7	26.1	149	34.9	41.0
Average	19.88	33.4	45	66.5	11.3	70	53.3	17.6

If the maximum permitted error for stand volume is ±8.0%, as it is now prescribed by the Regulations on the Elaboration of Forest Management Plans in Serbia, the number of sample should be 77. For the stand area of 25 ha, the intensity of measurement should be 15.4%, for the smaller stand, the intensity will be even higher, and for the stand of the larger area, the intensity will be lower.

The above examples show clearly that, for the prescribed precision of estimate of the stand volume (±10.0% or ±8.0%), a very high number of sample plots should be established in the stand, and this demands massive work and high costs of forest inventory.

6. CONCLUSION

The research of the variation and the precision (accuracy) of estimate of stand taxation elements in beech high forests on the localities of East and West Serbia makes it possible to draw the following conclusions:

- The variation and the precision of estimate of stand taxation elements in beech high forests are significantly different. On average, the variation coefficient amounts to: mean height 15%, mean diameter 21%, tariff series 26%, volume increment 26%, basal area 28%, tree number 33% and volume 34%. The achieved precision (accuracy) of estimate is: mean height ±6.8%, mean diameter ±10.5%, tariff series ±12.0%, volume increment ±12.0%), basal area ±13.4%, tree number ±15.8% and volume ±15.8%). The relative errors refer to the average stand area of about 20 ha, i.e. to the average number of sample plots in the sample (n = 20), with the size of the circular sample plots - 500 m^2. If the sample plot size is changed, the value of the variation coefficients also changes (smaller sample plots – higher variation, and larger sample plots – lower variation). This would be reflected on the determined precision (accuracy) of estimate. With the change of sample size, the value of relative errors of estimate of unchanged size of sample plot would be changed (with the decrease of sample, the error increases, and with the increase of sample, the error decreases). For the sample error to decrease k times, the size of sample should be increased approximately k^2 times.
- In the inventory of beech high stands (and the stands in general), in our opinion, we can tolerate the double relative error of volume ±10%. However, this is difficult to achieve, because it requires a large sample of sample plots to be established in the stand, i.e. massive work and financial means. A special problem is that this limit for the precision of volume estimate cannot be unique for all taxation elements and for all stands, irrespective of the their area. For this reason, the required accuracy of estimate for the stand should not be regulated in advance, but it should be identified after forest inventory data processing, in order to know the reliability of the determined data per hectare and on the total stand area. If the stand area is determined sufficiently accurately, the error of volume estimate per hectare and total volume will be equal. If there is an error of area, it must be taken into account.
- The selected size of sample plots of 500 m^2 and the sample size, by the system that one sample plot represents one hectare of the stand area, produced the satisfactory results in the study beech stands characterised by group-selection all-aged structure. Sample intensity accounted for 5% of the stand area. We are of the opinion that the given sample plot size and sample size can be implemented in beech high stands of similar structure. Thus the reliable results of forest inventory can be expected already at the level of management class with the area of about 200 hectares (double relative error of volume about ±5.0%). Of course, the accuracy will be the higher, the larger the area of the inventory unit, and the lower the error outside the sample (technical error).
- The variation of stand taxation elements is different, and the variation coefficient of volume is used in sample planning as the most significant taxation element. As it is easier to determine the variation coefficient of the stand basal area, it can also be used, but it should be multiplied by the coefficient 1.2. The required accuracy of estimate in planning the sample size, most often refers to the volume (e.g. ±10.0%), and the accuracy of other taxation elements is calculated from the sample. In the sample planning, the accuracy of other taxation elements can be assumed, as the ratio of the variation of the stand taxation elements is defined.

- Based on the presented results, it can be concluded that the achievement of the required precision of estimate, accounting for ±10.0% or ±8.0%, is related to the multiple increase of the size, i.e. sample intensity, and that it is not economically justified. For this reason, it should not be insisted on the demand of high accuracy of volume stand estimate. Also, in forest inventory, a unique network of sample plots should be used for all stands, because it is more practical than sample plot networks of different densities. In the former case, the sample size only on the stand area (volume variation is determined by experience), and in the latter case it depends on volume variation in the stand and the required precision of estimate.
- The demands regarding the precision (accuracy) of estimate of the most significant taxation elements should be established for the larger classification and management units (management classes, management units and forest areas).

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COMPARATIVE STUDY OF SCOTCH PINE AND AUSTRIAN PINE TREE DEVELOPMENT IN THE ARTIFICIALLY ESTABLISHED STAND ON THE SITE OF MONTANE BEECH FOREST IN THE AREA OF ČEMERNIK

Tatjana ĆIRKOVIĆ[1]

Abstract: *The comparative analyses of Scotch pine and Austrian pine tree development aged 31 years were performed in the artificial stand established on the site of montane beech forest in the area of Čemernik. The two species have similar courses of diameter and height increment only in the early youth. Already after the age of 10 years, Scotch pine has a more intensive diameter growth, so Scotch pine trees have larger diameters at breast height than Austrian pines from the age of 15 years till the final old age. Austrian pine, with the age, gradually lags behind also in height increment. Scotch pine height increment keeps the high value for a long time after the culmination due to the tree differentiation and its getting the dominant position in the stand, which ensures more light. Based on the analysis of diameter and height development, it can be concluded that Scotch pine is better in utilising the site productive potential and it reaches greater dimensions.*

Key words: artificially established stand, Scotch pine, Austrian pine, diameter, height, current increment

1. PROBLEM AND TASK

Coniferous plantations and artificial stands today occupy 155.135 ha, i.e. they account for 6,6% of the total growing stock in Serbia. The area under thee plantations and artificially established stands managed by SE "Srbijašume" is 99.050 ha, and their age is from 1 to 80 years. Plantations above the age of 20 years (the period when tending i.e. thinning should start) cover the area of 43.092 ha, i.e. 43,5%, and the plantations below 20 years occupy 55.958 ha, or 56,5% of the total area.

The most frequently established plantations are Austrian pine (*Pinus nigra* Arn.), spruce (*Picea abies* Karst.) and Scots pine (*Pinus silvestris* L.). Austrian pine plantations and artificial stands cover 52.585 ha, or 53,1% of the area, of which below 20 years – 48,3%, and above 20 years – 51,7% of the area under this species. The area under Scots pine is 9.860 ha, which is 10,0% of the total area of plantations and artificially established stands. The stands below 20 years cover 58,0%, and the older stands account for 42,0% (Medarević *et al.*, 2002).

Coniferous plantations and artificially established stands, their internal structure, environmental conditions, tending, etc., in Serbia were studied by Stojanović (1989-1990), Stojanović et Banković (1981), Krstić (1998), Stojanović et Krstić (1984), Jovanović et Stojanović (1982),

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Stamenković, *et al.* (1983), Stojanović *et al.* (1993, 2002), Dražić et Ratknić (1990), Vučković et Stamenković (1991), Koprivica *et al.* (1998), etc.

In the area of Čemernik, the area of coniferous plantations and artificially established stands managed by SE "Srbijašume" amounts to 3.052,32 ha, which is 23,7% of the total, i.e. 26,2% of the total area under forests in this area. In the coppice beech forests, the reconstruction was mainly performed by substitution, i.e. by replacing the beech of coppice origin by coniferous species., so about 90% of all artificial stands of conifers in MU "Kačer – Zeleničje" are in the belt of montane beech forests.

This study was performed in the artificial stand of Scots pine and Austrian pine established at the site of montane beech forest in the area of Čemernik. The paper presents the results of the comparative analyses of tree development of Scots pine and Austrian pine 31 years old, so as to study their differentiation in the stand and identify the time of the initiation of thinning in the aim of improving their development. The basic data on site characteristics and the present condition of the stand are also presented.

2. STUDY AREA AND METHOD

The researched artificially established stand of Scots pine and Austrian pine is situated in MU "Kačer – Zeleničje", compartment 121 d, at the altitude of 700 to 720 m, on Northwest to North-Northwest exposure, slope from 5 to 15°.

A series of sample plots were established in the stand for the phytocoenological research by Cvjetićanin during 2002 and for soil research by Knežević during 2001 and 2002. The stand was established on the site of montane beech forest (*Fagetum moesiacae montanum* B. Jov. 1953). The bedrock consists of schists, and the soil is leached acid brown soil. The canopy is from 0,5 to 0,6.

At the time of data collection (2000) the stand age was 31 years. The stand has a mixed composition – the percentage of Scots pine is averagely 71,2%, and Austrian pine 28,8% of the number of trees per hectare.

The climate and vegetation characteristics of Čemernik area were studied by Krstić et Ćirković (2005). According to Lang's bioclimatic classification, the climate is humid, and the forests are in their biological optimum. The average annual temperature is 7,7 °C, during the vegetation growth period 13,4 °C. The average annual precipitation is 805 mm, i.e. 449 mm during the vegetation period (55,8% of annual value).

The measurement and collection of taxation elements on permanent sample plots, as well as data processing, was performed by usual methods. For the dendrometric analysis of the diameter and height increment, three mean future trees were felled, which belong to the group of 20% of the largest Scots pine and Austrian pine trees in the stand.

3. RESULTS

3.1. The stand state

The average number of trees in the stand is 1.668 per ha, from 1.139 to 2.236. The average basal area is 44,41 $m^2 \cdot ha^{-1}$ (from 35,29 to 56,05 $m^2 \cdot ha^{-1}$), volume is 344,50 $m^3 \cdot ha^{-1}$ (from 276,55 to 431,98 $m^3 \cdot ha^{-1}$), and volume increment 11,67 $m^3 \cdot ha^{-1}$ (from 9,24 to 14,67 $m^3 \cdot ha^{-1}$). The high value of volume and volume increment is the consequence of the high production potential of the site, along with the stand homogeneity in the part in which the sample plots are established.

3.2. Tree development

3.2.1. Diameter development and diameter increment

The development of diameter and diameter increment of Scots pines and Austrian pines is presented in Diagram 1.

The test results of the statistical significance of differences in tree development and diameter increment (by F and t-test) are presented in Tables 1 and 2.

The diameter of 20% of the largest trees in the stand is on average 25,9 cm, 20% of the largest Scots pines – 26,8 cm (Scots pines also belong to the group of 1/5 of the largest trees in the stand), and Austrian pines – 22,0 cm.

The two species have similar courses of diameter increment only in the early youth. Already after the age of 10 years, Scotch pine has a more intensive diameter growth, so Scotch pine trees have larger diameters at breast height than Austrian pines from the age of 15 years till the final old age (there is a statistically significant difference).

The culmination of current diameter increment, i.e. 14,17 mm for Scots pine and 12,87 mm for Austrian pine, occurs between the ages of five and ten years. There is no statistically significant difference between the maximum values of diameter increment of the two species. After culmination, current increment decreases sharply due to the formation of the denser canopy and the absence of tending, so it does not exceed 6,00 mm for Scots pine and 4,00 mm for Austrian pine.

Average diameter increment of Scots pine culminates at the age of 15 years with the value of 9,33 mm, and of Austrian pine at the age of 10 years, when it is 8,20 mm.

These developments of diameter and diameter increment are similar to those in artificially established pine stands on beech sites in similar stand conditions reported by Stojanović et Banković (1981) on Povlen and Maljen, Stojanović et Krstić (1984) on Magleš, Vučković *et al.* (1990) in MU "Mučanj", Koprivica *et al.* (1998) in the area of Ivanjica, etc.

Diagram 1. Development of diameter and diameter increment

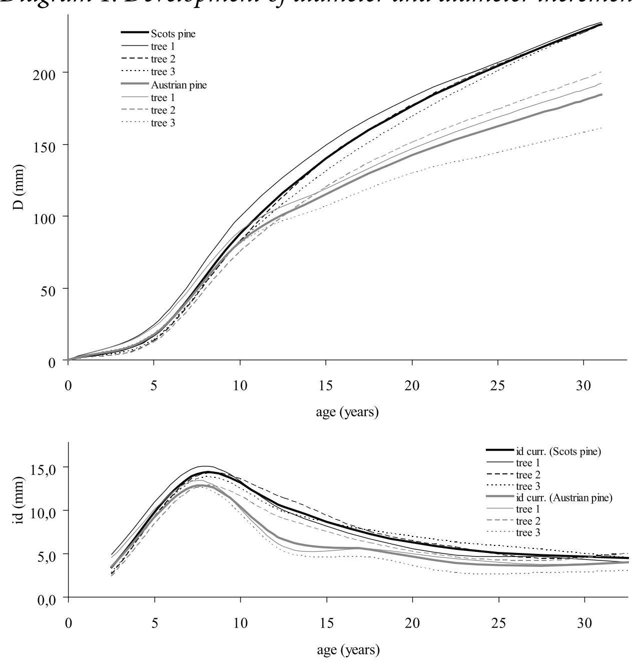


Table 1. Significance of differences in Scots pine and Austrian pine diameter development in a mixed artificially established stand of these species

Vrsta drveća		Age (years)					
		5	10	15	20	25	30
		Diameter (mm)					
SCOTS PINE		17,2	88,0	140,0	176,5	204,5	228,8
AUSTRIAN PINE		17,7	82,0	117,0	144,7	162,3	180,3
tcalc.		0,103	0,831	3,636	4,493	4,461	4,261
t(0,05; n1+n2-2)		2,776					
LSD	SCOTS PINE	*	*	*	*	*	*
	AUSTR. PINE	*	*	*	*	*	*

Table 2. Significance of differences in current diameter increment of Scots pine and Austrian pine trees in a mixed artificially established stand of these species

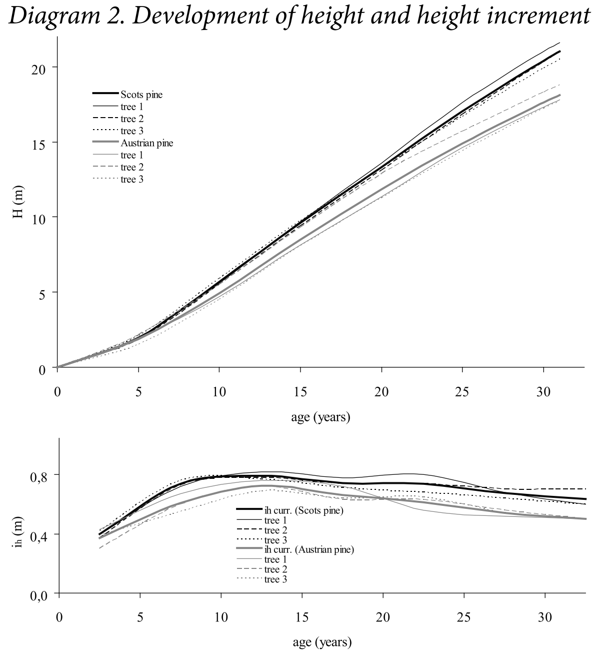
Tree species		Age (years)						
		0-5	5-10	10-15	15-20	20-25	25-30	30-35
		Current diameter increment (mm)						
SCOTS PINE		3,43	14,17+	10,40	7,30	5,60	4,87	4,50
AUSTRIAN PINE		3,53	12,87+	7,00	5,53	3,53	3,60	4,00
tcalc.		0,102	2,588	2,911	3,287	3,236	2,389	2,588
t(0,05; n1+n2-2)		2,776						
LSD	SCOTS PINE	*	*	*	*	*	*	*
	AUSTR. PINE	*	*	*	*	*	*	*

$^{+}$ - $i_{d\,curr.max.}$

3.2.2. Development of height and height increment

The development of height and current height increment of Scots pine and Austrian pine trees is presented in Diagram 2.

Diagram 2. Development of height and height increment



The results of the tested significance of differences in height development and increment (by F and t-test) are presented in Tables 3 and 4.

Table 3. Significance of differences in height development of Scots pine and Austrian pine trees in a mixed artificially established stand of these species

Tree species		Age (years)					
		5	10	15	20	25	30
		Tree height (m)					
SCOTS PINE		1,98	5,67	9,62	13,38	17,03	20,37
AUSTRIAN PINE		1,87	4,90	8,52	11,83	14,90	17,60
tcalc.		0,568	2,538	2,703	3,296	4,315	5,596
t(0,05; n1+n2-2)		2,776					
LSD	SCOTS PINE	*	*	*	*	*	*
	AUSTR. PINE	*	*	*	*	*	*

Table 4. Significance of differences in current height increment of Scots pine and Austrian pine trees in a mixed artificially established stand of these species

Tree species		Age (years)						
		0-5	5-10	10-15	15-20	20-25	25-30	30-35
		Current height increment (m)						
SCOTS PINE		0,40	0,74	0,79+	0,75	0,73	0,67	0,67
AUSTRIAN PINE		0,37	0,61	0,72+	0,66	0,61	0,54	0,50
tcalc.		0,568	3,958	2,595	5,096	2,249	4,750	5,000
t(0,05; n1+n2-2)		2,776						
NZR	SCOTS PINE	*	*	*	*	*	*	*
	AUSTR. PINE	*	*	*	*	*	*	*

$^{+}$ - $i_{h\ curr.max.}$

The lines of height development show that Austrian pine with the age, gradually lags behind in height increment, and from the age of 25 years, the difference becomes statistically significant, compared to Scots pine height increment.

Both species reach the maximum value of current height increment between the ages of ten and fifteen years, when Scots pine exceeds 0,79 m, and Austrian pine 0,72 m (there is no statistically significant difference). After the culmination, Scots pine increment keeps the high value for a long time, thanks to the differentiation and its dominant position in the stand, which ensures more light, and time and more favourable conditions of growth and development. Current height increment of Austrian pine constantly decreases, and after the age of 30 years, it is 0,50 m.

Average height increment of both Scots pine and Austrian pine culminate at the same time, at the age of 25, but Scots pine trees have higher maximal absolute values amounting to 0,68 m, while Austrian pine value is 0,60 m.

Just as in the case of the development of diameter and diameter increment, our results on height and height increment in the study stand agree with the results in artificially established pine stands reported by Stojanović et Banković (1981), Stamenković *et al.* (1983), Stojanović et Krstić (1984) Vučković *et al.* (1990), Koprivica *et al.* (1998), etc.

4. CONCLUSIONS

The development and increment of 20% of the largest Scots pine and Austrian pine trees, aged 31 years, grown in artificial stand established at the site of montane beech forest of high production potential was analysed in the area of Čemernik.

In the first years, there is no difference in the diameter and height development of the two species. The differentiation and the predominance of Scots pine compared to Austrian pine occur after the age of fifteen and it increases with the age. The culmination of current increment, of both diameter and height, starts at about the same time for both species. Diameter increment reaches the maximum between the ages of five and ten, and height increment slightly later, between the ages of ten and fifteen years. Although Scots pine maximum current increment is higher than that of Austrian pine, there is no statistically significant difference between them.

The researched stand is not tended, and the first thinning should have been performed when the height of Scots pine dominant trees was about 5,7 m, about the age of 10 years, so as to maintain the high increment value as long as possible..

Based on the analysis of diameter and height development it can be concluded that Scots pine reaches greater dimensions, thanks to the bio-ecological characteristics of this species and its better utilisation of the site production potential.

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APPLICATION OF REMOTE SENSING IN THE COLLECTION OF SPATIAL DATA ON FORESTS AND FOREST ECOSYSTEMS

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Abstract: *The presented method can have high usefulness in the collection of spatial data on forests and forest ecosystems. The greatest part of information is obtained based on high resolution satellite imagery, which will reduce the processing costs many times.*

Key words: satellite image, forests, forest ecosystems

1.INTRODUCTION

The status of forests and forest ecosystems, the goals of management, the type and volume of works, as well as the measures for achieving the goals of management are determined for territorial units of different sizes (management units, municipalities, cadastral municipalities and cadastral parcels). The data has to enable the owner or user to improve his holding. The method presented in this paper provides the usable data on the state of forests and forest ecosystems based on which the type and the volume of works can be assessed in each selected area. It enables the application of the method "from minor to major" with the minimal field work. The problem is especially high in the data collection on private forests, because of a high number of parcels (average size about 50 ares). In Serbia there are about 500,000 private forest owners, which require the processing of a great number of data and a high level of accuracy.

2. APPLICATION OF SATELLITE IMAGERY IN SPATIAL DATA COLLECTION

In the collection of spatial data, the application of multi-spectral satellite imagery of high resolution enables the production of plans at the scale 1:5.000 and higher. The aim is to obtain most of the data in the digital format and to maximally reduce the collection of data which require field measurements.

In the process of data collection and processing, it is necessary to perform the following activities:

a) Selection of images
b) Determine the number of images that cover the study area (municipality)
c) Field measurements (determination of reference and control points)
d) Analysis of satellite images
e) Drawing up of the plans.

The processing of satellite images in the preparation phase consists of:

1. Mosaic of satellite images which cover the study area
2. The areas which are not analysed are presented by 10% darkening (urban areas, farmland areas, etc.).

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3. Selection of unproductive areas (road, riding cut, yard, rocks, pool, stream, channel, river, fishpond, lake, swamp, waterlogged soil, reeds, saline soil, peatland, historical monument, transmission line, sport playground, terrain for sport and recreation, parking, camping, buildings and other structures, cemetery, ski path, cableway, walking path, trimming path, quarry, gravel pit, opencast mine, borehole, etc.).

For the remaining areas, the cadastral plans (analogous forms) are transformed into the digital format and they are included as a separate layer in the content of the satellite image. The input data are also the municipality boundary, boundaries of cadastral municipalities and boundaries of cadastral parcels. The areas which are outside the boundaries of the study area are darkened 10%.

In the following phase of image processing, the homogeneous zones are formed of several site and stand parameters which can be interpreted from the image, and which are necessary for further data processing.

In the analysis and interpretation of the data from the satellite images of high resolution, two classification processes are applied in the site class assessment:

- Supervised classification process of site data takes into account the data from the field measurements and compares them with the data obtained by the application of this classification process.
- Unsupervised classification process of site data takes into account the data from the updated topographic and other maps and compares them with the data obtained by the application of this classification process.

The site characteristics include parent rock, soil characteristics, vegetation and orographic characteristics of the study area. The analysed data are presented in the cartographic form in the form of layers, which enables map overlaying and the selection of zones of the same ecological characteristics. The data on site characteristics can be obtained by the analysis of multispectral channels of high resolution images, and their reliability is confirmed by the field data.

The classes selected as site characteristics are:

Parent rock: parent rock is determined in combination with the geological map presented in the digital format.

Soil type, depth, skeletalness and moisture during imaging is determined based on the geological map and soil map in digital format, based on the field data and by the analysis of infrared (thermal channel) – by the parcel and/or grid cell and/or spatial representation.

Figure 1. Crown projection measurement

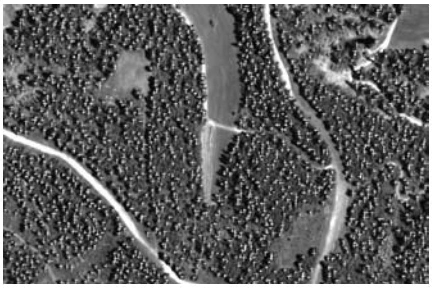
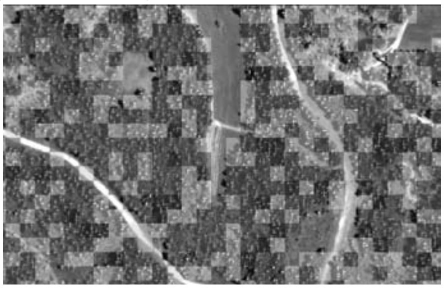


Figure 2. **Homogeneous zone formation**



Elevation (contour lines or presentation by zones of 100 metres) – (by the analysis of high resolution digital satellite imagery - automatic – ERDAS 3D or by the analysis of stereo aerophoto imagery by restitution – D.W.D.).

Slope (in percentage) – (singled out from DMT – by parcel and/or grid cell and/or spatial representation).

Exposure (from DMT – by parcel and/or grid cell and/or spatial representation). The classes of exposure are: without slope, north, northeast, east, southeast, south, southwest, west, northwest.

The acquisition of data on forests and forest ecosystems requires all the details which can be acquired by the interpretation of high resolution satellite imagery, with the minimal fieldwork. A space is left for the field data and the data collected by the digital photo camera, by which the data which are not registered by satellite images are corrected.

The first step in forest classification on the satellite image is the demarcation of the boundaries of the areas which differ by tree species, spatial distribution, and by the degree of canopy closure. The formed homogeneous entities are then broken down by other criteria or by the mapping scheme (for example into cadastral parcels).

Spectral and spatial analyses of data are applied in addition to classical interpretation, in the processing of satellite images aiming at the classification of forests and forest ecosystems.

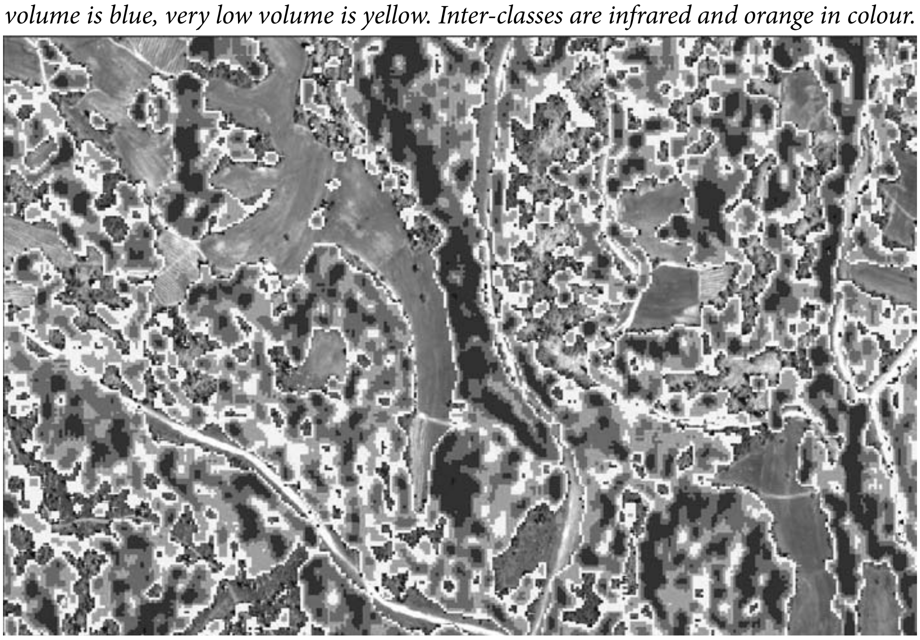
The following data are measured on the high resolution satellite images (pixel < 1 m):

- crown projection,
- total tree height (if slant infrared satellite channel is used),
- thinned stand, and
- tree number.

The above values, with sufficient accuracy, can replace the direct field measurements. They are used as input data in volume tables and their correlation with tree and stand volume is satisfactory.

Stand volume can be estimated with sufficient precision, which enables the stand classification by volume per unit area. The categories classified by volumes produce efficient stratification units which provide the base for field estimates.

Figure 3. The volume depending on stand canopy determined from a satellite image. High volume is blue, very low volume is yellow. Inter-classes are infrared and orange in colour.



During the analysis of satellite images, it is necessary to visit the area for which the accuracy of data interpretation is doubtful. The results are occasionally controlled, in order to set the critical limit of acceptable errors.

In the collection of volume data in the field, the circles should be of invariable area, i.e.: for high forests, diameter 12.62 m (5 ares), for coppice forests, 7.98 m (2 ares), for thickets and brushland, 5.64 m (1 are).

The volume can be directly estimated from satellite images at the following scales:

- 1:30,000 for area reconnaissance,
- 1:15,000 for planning (forest management),
- 1: 5,000 for data presentation at the level of the cadastral parcel.

The field reconnaissance is desirable regardless of the accuracy of satellite images. For extensive measurements, it is sufficient to construct one or several volume tables which correspond to a group of species. Each species (or group of species) for which volume tables are constructed should be identified on the images.

The samples on which stand characteristics are measured are distributed and demarcated on the image by a model, which ensures a constant size of the sample plots. They are distributed on a homogeneous unit (class) systematically or randomly. Crown diameter is measured of all visible trees. Each area is classified, and the volume of large trees is read from the tables.

If underwood trees, which belong to commercial dimensions, are not visible and available for measurement, the calculated volume should be increased. This problem can be solved by processing the satellite images in two time periods or field measurements.

The classes which are identified within stand characteristics are:

Tree species and stand classification can be identified by the unsupervised process of classification. By the application of multispectral satellite images, and based on their spectral and spatial processing, the following classes can be identified: 1. Forest of black and grey alders, 2. Forest of willows, 3. Forest of poplars, 4. Forest narrow-leaved ash, 5. Forest of common oak, 6. Forest of hornbeam, 7. Forest of Turkey oak, 8. Forest of Hungarian oak, 9. Forest pubescent oak, 10. Forest of common oak with Tartar maple, 11. Forest of oriental hornbeam and hop hornbeam, 12. Forest of lime, 13. Forest of sessile oak, 14. Forest of birch, 15. Forest of beech, 16. Forest of pines, 17. Forest of fir, spruce and beech, 18. Forest of spruce, 19. Forest of Serbian spruce, 20. Forest of white-bark pine, 21. Forest of mountain pine, 22. Artificially established stands.

Canopy – (by parcel and/or grid cell and/or spatial representation) (time – before vegetation growth period): 1. very dense; 2. dense 0.8-0.9; 3. complete 0.7; 4. incomplete 0.6; 5. sparse 0.5; 6. very sparse 0.4; 7. scattered, below 0.4).

Development phase (Age) – (by the analysis of satellite multispectral images – by parcel and/or grid cell and/or spatial representation).

Stand origin – (based on field data 1-3, i.e. based on imagery 4-9): 1. high, 2. coppice, 3. mixed origin, 4. forest for fodder, 5. forest litter, 6. scrub forest, 7. brushwood, 8. pseudo maquis, 9. maquis.

Stand conservation – (calculated from the stand canopy and stand origin): 1. conserved, 2. thinned, 3. devastated – over-thinned stand.

Stand mixture – (by the analysis of satellite infrared imagery – by parcel and/or grid cell and/or spatial representation): 1. pure, 2. mixed.

Stand structure – (based on satellite images 1-4, based on the image and field data 5): 1. tree selection, 2. group selection, 3. circles, 4. strips, 5. storeys.

Planting density – (by parcel and/or grid cell and/or spatial representation; analysis of ortho-photo plan) 1x1, 2x2, 3x3, 4x3, 5x5, 6x3, 6x6.

By the application of the above method which is being developed, the fieldwork is mainly concentrated on the checking of the data collected by satellite imagery. The zones with identical site and stand characteristics are known in advance (the strata are formed) and the samples on stand production characteristics are taken from them. For each cadastral parcel, the exact tree number per species is determined.

3. CONCLUSIONS

Information on forests and forest ecosystems are multidisciplinary. The quantity of information is permanently increasing, which requires the organisation of the system of collection, processing and archiving of the information. Consequently, an integral approach is necessary in the establishment of the information system. Information system has to be able to unite the collection, systematisation, selection, classification and updating the information on all elements of forests and forest ecosystems.

Digital processing of satellite images ensures the collection of relevant data which enable the utilisation of forests and forest ecosystems on the principles of sustainable development.

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QUALITY AND ASSORTMENT STRUCTURE OF THE VOLUME OF BEECH HIGH STANDS IN JABLANIČKO FOREST AREA

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Abstract: *The quality and assortment structure of beech high uneven-aged stands in Jablaničko forest area in South Serbia were researched. The study area consists of two representative stands classified as beech montane forest (Fegetum moesiacae montanum). The field data were collected by the systematic sample of sample plots. The tree quality was assessed by a special classification, and the assortment structure was evaluated by assortment tables. It was concluded that the percentage of the low quality classes in the study stand volume was high (53%- the third silvicultural class and 33%- the third and fourth technical classes), and that the percentage of technical wood in gross volume was 39%, cordwood 51% and waste 10%.*

Key words: beech, stand, quality, assortment, structure

1. INTRODUCTION

In Serbia, forest inventory to date has most often been focused on the value and structure of the basic taxation elements (tree number, basal area, volume and volume increment). Little attention has been devoted to the assessment of the quality and assortment structure of the volume of the stands and the larger forest classification and management units. In forest management plans, the data on the stand quality structure are given descriptively, and the assortment structure is concluded based on the experience gained during the forest production in the region. However, both methods are too subjective and there is a permanent need for the implementation of a more objective method. The textbook on dendrometry describes numerous methods developed to this purpose (Mirković, D., Banković, S., 1993). Different methods have different reliability and practical implementation potentials. For this reason, the Institute of Forestry in Belgrade has conceived a scientific project under the title “Method of assessment of quality and assortment structure of beech high stands in Serbia“. After two years of research, we can present a part of the study results for Jablaničko forest area.

2. STUDY AREA AND METHOD

The research was performed in two beech high uneven-aged stands: stand 31a was selected in the Management Unit “Kačer-Zeleničje“, and stand 46a was selected in Management Unit “Kukavica I“. The main characteristics of the stands are:

Stand 31a, area 32.44 ha, is situated at the altitude of 870–1030 m, slope 15–40 degrees. Most frequent exposures are Northwest and West. Parent rock consists of gneiss in the process

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of weathering, dystric brown soil, depth 40–80 cm. The stand belongs to beech montane forest (*Fagetum moesiacae montanum*); its silvicultural and structural form is beech high group-selection uneven-aged stand. Site class is II, canopy 0.69, percentage of beech in the volume 99.7%, mean diameter per basal area 30.2 cm, and Lorey's mean height 23.7 m.

Stand 46a, area 28.33 ha, it is situated at the altitude of 780–1020 m, slope 15-40 degrees. Most frequent exposures are Northwest and North. Parent rock consists of gneiss, soil type is humus siliceous eutric soil, depth 40–80 cm. This stand is also a beech montane forest. Its silvicultural and structural form is beech high group-selection uneven-aged stand. Site class is II/III, canopy 0.87, percentage of beech in the volume 99.4%, mean diameter per basal area 31.5 cm, Lorey's mean height 24.0 m.

A special method was designed (Koprivica *et al.*, 2005) for the collection and data processing for the research of quality and assortment structure of beech high stands in Serbia. We shall present only the basic characteristics of the method, for better understanding of the study results and conclusions. The size and structure of taxation elements, and especially the volume and its quality and assortment structure, were determined by partial measurement. The elements of the simple (systematic) sample are simple circular sample plots, sized 500 m^2 (radius 12.62 m), distributed in the stand in the grid network, spacing 100 metres. The intensity of measurement was 5% of the stand area, i.e. one sample plot represents one hectare. The quality of the trees on sample plots was evaluated after Matić's classification (Matić, V., 1977). Actually, there are two classifications: silvicultural-technical (classes 1, 2 and 3) and technical (classes 1, 2, 3 and 4). The provisional marking of the trees for felling, was performed exclusively for silvicultural purposes, to increase the size and quality of wood production (the principle of positive selection). The data collected in the stands were basically processed by the method reported by Koprivica, Matović, B. (2005), and the final processing was performed by the designed method (Koprivica *et al.*, 2005). The assortment structure was assessed by Vukmirović's stand assortment tables (Vukmirović, V., 1971), with some corrections (Koprivica *et al.*, 2005).

3. RESULTS

Of all the numerous study results, we shall present only the results on the value and structure of the basic taxation elements, with the focus on stand volume.

3.1 Size and structure of beech stand taxation elements per diameter classes

The size and structure of the number of trees, basal area, volume and volume increment (per diameter classes and hectare) are presented in Table 1.

Table 1. Structure of basic taxation elements in beech stands per diameter classes

Diameter class (cm)	Stand 31a				Stand 46a			
	N (pcs)	G (m2)	V (m3)	Iv (m3)	N (pcs)	G (m2)	V (m3)	Iv (m3)
10-20	126.3	2.20	13.72	0.38	137.1	2.33	15.53	0.84
20-30	66.2	3.16	30.98	0.82	58.6	2.85	29.54	1.57
30-40	46.9	4.58	61.84	1.48	36.4	3.54	46.49	1.78
40-50	46.2	7.24	111.23	2.42	30.0	4.58	66.27	2.20
50-60	8.1	1.86	31.86	0.59	25.0	5.76	91.53	2.38
60-70	6.3	2.00	32.49	0.56	7.9	2.57	41.72	0.80
70-80	1.3	0.50	8.73	0.09	3.6	1.58	24.92	0.49
Total	301.3	21.54	290.85	6.34	298.6	23.21	316.00	10.06

The stands have a declining distribution of the number of trees per diameter classes (diameter structure). The number of trees per hectare is almost equal (about 300). The differences in basal area and stand volume are not great, but the difference in volume increment is very high (about 3.7 m^3/ha). The distribution of stand volume per diameter classes is one of the parameters of the quality and assortment structure – in the sense that, at the approximately the same quality of healthy trees, the stand with a higher percentage of larger diameter trees is more valuable. Aiming at the better appreciation of the differences between stand volume structures per diameter classes, their percentage distribution is presented in Table 2.

Table 2. Percentage distribution of beech stand volumes per diameter classes

Stand	Diameter class (cm)							Total
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	(%)
31a	4.7	10.7	21.3	38.1	11.0	11.2	3.0	100.0
46a	4.9	9.4	14.6	21.0	29.0	13.2	7.9	100.0

Table 2 shows that 25.2% of the volume in stand 31a is above 50 cm, and as much as 50.1% in stand 46a, so it could be assumed that the stand 46a has a better quality and assortment structure, but this is not certain.

The volume of the trees included in the provisional marking in the stands is presented in Table 3.

Table 3. Distribution of the provisionally marked volume in the stands per diameter classes

Stand	Diameter class (cm)							Total
	10–20	20–30	30–40	40–50	50–60	60–70	70–80	(m3 and %)
31a	8.89	14.12	18.39	39.58	15.13	25.82	8.73	130.66
	6.80	10.80	14.00	30.30	11.60	19.80	6.70	100.00
46a	7.53	12.02	20.97	22.64	39.34	30.35	24.92	157.77
	4.80	7.60	13.30	14.40	24.90	19.20	15.80	100.00

Table 3 shows that of the total marked volume, the percentage of the trees with diameters above 50 cm in stand 31a is 38.1%, and in stand 46a, as much as 59.9%. This is in harmony with the percentage distribution of the stand volume. Also, marked trees are distributed in all diameter classes, which supports the previous conclusion that the trees were marked from the aspect of silviculture (tending).

3.2 Quality structure of beech stand volume

The study results include the quality structure of stand volume, provisionally marked volume, and the volume of the stand which would remain after the marked trees have been felled.

Table 4 presents the percentage distribution of stand volumes per silvicultural and technical classes.

Table 4. Quality structure of beech stand volume

Stand	Silvicultural class (%)				Technical class (%)				
	1.	2.	3.	Total	1.	2.	3.	4.	Total
31a	17.3	35.1	47.6	100.0	37.7	31.4	17.4	13.5	100.0
46a	5.0	35.6	59.4	100.0	25.3	39.2	22.0	13.5	100.0
Total	11.6	35.3	53.1	100.0	31.9	35.1	19.5	13.5	100.0

Table 4 shows that the volume quality structure is better in stand 31a compared to stand 46a. However, quality structure of both stands can be evaluated as very unfavourable, because the percentage of the third (the lowest) silvicultural class is high, as well as the third and fourth (the lowest) technical classes. This resulted in an exceptionally high intensity of the provisionally marked volume, which in stand 31a accounts for 44.9% and in stand 46a as much as 49.9%. Practically, about half of the stand volume is poor quality, as the consequence of the absence of the adequate tending in the past.

Table 5 presents the quality structure of the provisionally marked volume, in the same way as for the stand volumes in the previous Table.

Table 5 shows that provisional marking is concentrated mostly on the trees of the third silvicultural class (about 83% per volume), and considerably less on the trees of the second class, and insignificantly on the first silvicultural class. The share of the third and fourth technical classes in the provisionally marked volume accounts for about 54%. Therefore, quality structure of the provisionally marked volume is much more unfavourable than the quality structure of the stand volume, and this could have been expected.

Table 5. Quality structure of the provisionally marked volume in beech stands

Stand	Silvicultural class (%)				Technical class (%)				
	1.	2.	3.	Total	1.	2.	3.	4.	Total
31a	0.5	20.0	79.5	100.0	15.2	29.7	27.1	28.0	100.0
46a	-	13.7	86.3	100.0	0.8	46.1	27.2	25.9	100.0
Total	0.2	17.1	82.7	100.0	8.5	37.4	27.1	27.0	100.0

Table 6 presents the quality structure of unmarked stand volume, in the same way as for the present stand volume and the provisionally marked volume of the trees for felling.

Table 6. Quality structure of unmarked volume of beech stands

Stand	Silvicultural class (%)				Technical class (%)				
	1.	2.	3.	Total	1.	2.	3.	4.	Total
31a	31.0	47.4	21.6	100.0	56.1	32.7	9.5	1.7	100.0
46a	10.0	57.4	32.6	100.0	49.7	32.5	16.7	1.1	100.0
Total	21.2	52.1	26.7	100.0	53.1	32.6	12.9	1.4	100.0

The data in Table 6 show the quality structure of the volume which should be realised in the next two to three management periods (20–30 years) by applying the stand tending principle of the positive selection of trees. Then the tree quality, i.e. their volume in the stands, would be much better than the present quality.

3.3 Assortment structure of the beech stand volume

Assortment structure of the present volume, provisionally marked volume and unmarked stand volume is calculated by stand assortment tables for beech (Vukmirović, V., 1971). The inputs in these tables are diameter class (diameter at breast height) and technical class. The Tables were corrected (Koprivica *et al.*, 2005) because this research covers the volume of trees above 3 cm at the thinner end.

Tables 7.1 and 7.2 present the assortment structure of the present stand volume.

Assortment structure of the present volume is better in stand 31a compared to stand 46a. In stand 31a, the percentage of the most valuable products (veneer logs, rotary logs and saw logs of the first class) is 14.5%, and in the stand 46a, it is 12.5%. The percentage of technical wood in the volume of the stand 31a is 39.06%, cordwood 50.98%, and waste 9.96%. In the stand 46a, the percentage of technical wood is 38.15%, cordwood 51.44%, waste 10.41%. Still, it has to be concluded that the assortment structure of the study stands is very similar and that, in this respect, they can be analysed together. The ratio of the main groups of products is the following: technical wood 38.6%, cordwood 51.2% and waste 10.2% of the total (gross) stand volume.

Table 7.1 Assortment structure of the present volume, stand 31a

Diam. class (cm)	Vol. (m3/ha)	Volume of products and waste (m3/ha)								
		FT/TL	PT1	PT2	PT3	C	O1 O2	O3	S	OTP
10–20	13.72	–	–	–	–	3.23	4.85	2.78	1.43	1.43
20–30	30.98	–	–	1.39	2.01	9.48	8.16	4.12	2.84	2.98
30–40	61.84	2.35	4.56	7.36	9.48	12.31	8.32	6.78	5.00	5.68
40–50	111.23	9.03	12.92	14.78	16.33	16.56	11.33	12.37	7.28	10.63
50–60	31.86	3.94	3.65	4.22	4.53	4.18	2.94	3.62	.71	13.07
60–70	32.49	2.60	2.94	4.40	4.76	4.57	3.73	4.46	1.34	3.69
70–80	8.73	–	0.12	0.58	1.67	1.32	1.72	.55	01.26	1.51
Total	290.85	17.92	24.19	32.73	38.78	51.65	41.05	35.68	19.84	28.99
(%)	100.0	6.16	8.32	11.25	13.33	17.76	14.12	12.27	6.83	9.96

Legend: FT –veneer log, TL- rotary log, PT – saw log, OTP - waste

Table 7.2. Assortment structure of the present volume, stand 46a

Diam. class (cm)	Vol. (m3/ha)	Volume of products and waste (m3/ha)								
		FT/TL	PT1	PT2	PT3	C	O1 O2	O3	S	OTP
10-20	15.53		-	-	-	4.01	5.35	3.02	1.60	1.55
20-30	29.54	-	-	1.27	1.91	8.93	7.81	4.00	2.70	2.92
30-40	46.49	1.47	3.02	4.54	6.73	9.42	7.30	5.70	3.58	4.73
40-50	66.27	4.30	6.44	8.38	9.91	10.62	7.55	7.98	4.27	6.82
50-60	91.53	6.70	8.55	13.70	14.16	13.72	9.31	11.20	4.88	9.31
60-70	41.72	2.46	3.46	6.08	6.48	6.17	4.75	6.00	1.65	4.67
70-80	24.92	0.89	2.08	4.35	3.71	3.11	2.96	4.15	0.79	2.88
Total	316.00	15.82	23.55	38.32	42.90	55.98	45.03	42.05	19.47	32.88
(%)	100.0	5.00	7.45	12.13	13.57	17.72	14.25	13.31	6.16	10.41

Assortment structure of the provisionally marked volume is presented in the same way as the assortment structure of the present stand volume (Tables 8.1 and 8.2).

Table 8.1. Assortment structure of the provisionally marked volume, stand 31a

Diam. class (cm)	Vol. (m3/ha)	Volume of products and waste (m3/ha)								
		FT/TL	PT1	PT2	PT3	C	O1 O2	O3	S	OTP
10–20	8.89	–	–	–	–	1.87	3.15	1.94	0.93	.00 1
20–30	14.12	–	–	0.43	0.82	3.87	4.09	2.08	1.28	1.55
30–40	18.39	0.30	0.49	1.57	2.91	3.93	3.40	2.41	1.42	1.97
40–50	39.58	1.44	2.56	4.50	6.06	7.04	5.36	5.50	2.49	4.63
50–60	15.13	0.97	1.21	1.95	.25 2	2.41	1.79	2.02	0.79	1.74
60–70	25.82	1.76	2.07	3.31	3.83	3.79	3.22	3.69	1.04	3.11
70–80	8.73	–	0.12	0.58	1.67	1.32	1.72	1.55	0.26	1.50
Total	130.66	4.47	6.45	12.34	17.54	24.23	22.73	19.19	8.21	15.50
(%)	100.00	3.42	4.93	9.45	13.43	18.55	17.39	14.69	6.29	11.85

Table 8.2. Assortment structure of the provisionally marked volume, stand 46a

Diam. class (cm)	Volume (m3/ha)	Volume of products and waste (m3/ha)								
		FT/TL	PT1	PT2	PT3	C	O1O2	O3	S	OTP
10–20	7.53	–	–	–	–	1.38	2.66	1.77	0.79	0.93
20–30	12.02	–	–	0.18	0.57	2.86	3.97	1.94	1.09	1.41
30–40	20.96	0.27	0.43	1.22	3.21	4.32	4.34	3.07	1.53	2.57
40–50	22.65	0.30	0.82	2.22	3.48	4.42	3.53	3.57	1.37	2.94
50–60	39.34	1.01	2.54	5.79	6.37	6.77	4.81	5.46	2.02	4.57
60–70	30.35	0.76	1.88	4.32	4.92	4.93	3.92	4.78	1.14	3.70
70–80	24.92	0.89	2.08	4.35	3.71	3.11	2.96	4.15	0.79	2.88
Total	316.00	15.82	23.55	38.32	42.90	55.98	45.03	42.05	19.47	32.88
(%)	100.0	5.00	7.45	12.13	13.57	17.72	14.25	13.31	6.16	10.41

The data in Tables 8.1 and 8.2 show that the assortment structure of the provisionally marked volume is somewhat more favourable in stand 31a compared to stand 46a. In stand 31a, the percentage of the most valuable products (veneer logs, rotary logs and saw logs of the first class) is 8.3%, and in the stand 46a, it is 7.0%. In stand 31a, the percentage of the main groups of products is the following: technical wood 31.2%, cordwood 56.9%, waste 11.9%, and in stand 46a: technical wood 32.5%, cordwood 55.4% and waste 12.1%. However, it is seen that the assortment structure of the provisionally marked volume in the study stands is similar and that, in this respect, they can be analysed together. In this case, the provisionally marked volume has the following assortment structure: technical wood 31.8%, cordwood 56.2% and waste 12.0%.

In the end of the analysis of the stand assortment structure, it is interesting to see the assortment structure of the unmarked volume. Due to the limited scope of this paper and as it is possible to calculate the structure per diameter classes from the above Tables, we shall present only the total percentage of the products (Table 9).

Table 9: Assortment structure of unmarked volume in beech stands

All diam. classes	Vol. (m3/ha)	Volume of products and waste (m3/ha)								
		FT/TL	PT1	PT2	PT3	C	O1 O2	O3	S	OTP
Stand 31a										
Total	160.19	13.45	17.75	20.38	21.24	27.42	18.33	16.49	11.64	13.49
(%)	100.00	8.40	11.08	12.72	13.26	17.12	11.44	10.29	7.27	8.42
Stand 46a										
Total	158.23	12.58	15.80	20.26	20.64	28.20	18.84	17.30	10.74	13.87
(%)	100.00	7.95	9.99	12.80	13.04	17.82	11.90	10.93	6.79	8.78

The data in Table 9 show that there is a small difference in assortment structure of unmarked volume. The percentage of the best-quality products (FT, TL and PT1) in stand 31a is 19.5%, and in stand 46a - 17.9%. The percentage of the main groups of products in the unmarked volume, stand 31a, is as follows: technical wood 45.5%, cordwood 46.1% and waste 8.4%, and in stand 46a: technical wood 43.8%, cordwood 47.4% and waste 8.8%. Together, for both stands, assortment structure is as follows: technical wood 44.7%, cordwood 46.7%, and waste 8.6%.

4. DISCUSSION AND CONCLUSION

Previous analyses of quality and assortment structure of the study stands show that the stands, in this respect, can be analysed together. At this level, the quality and assortment structure of the present volume, provisionally marked volume and unmarked volume are compared (Tables 10 and 11).

Table 10. Quality structure of the volume of beech stands, together

Stand volume	Silvicultural class (%)				Technical class (%)				
	1.	2.	3.	Total	1.	2.	3.	4.	Total
Present	11.6	35.3	53.1	100.0	31.9	35.1	19.5	13.5	100.0
Marked	0.2	17.1	82.7	100.0	8.5	37.4	27.1	27.0	100.0
Unmarked	21.2	52.1	26.7	100.0	53.1	32.6	12.9	1.4	100.0

Table 11. Assortment structure of the volume of beech stands, together

Stand volume	Assortments and waste (%)								
	FT/TL	PT1	PT2	PT3	C	O1 O2	O3	S	OTP
Present	5.62	7.91	11.64	13.44	17.74	14.18	12.75	6.52	10.20
Marked	2.78	4.92	10.38	13.75	18.11	17.02	15.16	5.94	11.94
Unmarked	8.19	10.57	12.76	13.16	17.45	11.65	10.59	7.04	8.59

The data in Tables 10 and 11 show that the tree quality in beech stands in Jablanički forest is not satisfactory (defined by diameter and quality), i.e. their volume. The improvement of their quality and assortment structure should be permanent, by the implementation of the appropriate management system, i.e. tending. As these are beech pure uneven-aged stands, the group-selection stand structure should be attained. This results from the present stand structure and the steep slopes on which the stands are situated.

The relatively poor quality of the trees is reflected on their assortment structure, i.e. the structure of the present volume, provisionally marked volume and unmarked volume in the stands. The percentage of the main groups of products in the above three states of the stand volume is the following:

Stand volume	Technical wood (%)	Cordwood (%)	Waste (%)
Present	38.6	51.2	10.2
Marked	31.8	56.2	12.0
Unmarked	44.7	46.7	8.6

As beech stands in Jablaničko forest area have not been adequately tended and because of the still significant percentage of larger diameter trees (above 60 cm - diameter of felling ripeness), which are most often of poor quality (partly decayed and hollow), there is a high difference between the quality and assortment structure of the present stand volume and the provisionally marked volume – exclusively from the aspect of silviculture.

To improve the present unfavourable quality and assortment of beech stand structure in Jablaničko forest area, tending should be persistant in all management periods. In two to three decades, the quality and assortment structure of the stand volume could be significantly improved. In forest management, the desired quality and assortment structure should be that of the unmarked stand volume presented in this paper.

As all the previous results were based on the sample of sample plots, they should be taken as the most probable, but not also as completely accurate. In harmony with the theory of samples, under the same sample intensity, the accuracy of data will increase with the increase of the measured forest area, i.e. with the increase of the sample size for the same forest area. The issue of reliability of the results of beech high stand inventory by sample method was reported in the paper (Koprivica, 2006).

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STATUS OF WILD LIFE AND PROBLEMS IN MANAGEMENT OF GAME PRESERVE IN ĐERDAP NATIONAL PARK

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Abstract: *National park Đerdap is the largest National Park in Serbia. It occupies the right bank of the Danube along the border of the Republic with Romania. These are extraordinarily rich terrains and the domicile of diverse game.*

The area of the hunting ground of the National Park Đerdap is 68,608.45 ha. NP Đerdap hunting ground today manages about 300 deer, somewhat more than 740 roe deer, more than 250 wild boars, somewhat above 100 chamois, about 1000 hares, and about 250 partridges.

Generally, the state and the quality of the raised game species in the National Park are good, and the trophy value of the deer and wild boar is excellent. With the minor investments in the feeding potential of the site, the present state of the game growing stock would be largely improved.

Key words: National Park Đerdap, game, hunting ground, species, state, growing stock, density

1. INTRODUCTION

Đerdap National Park is the largest national park in Serbia stretching along the right bank of the Danube in the area bordering with Romania.

The area of Đerdapska Klisura was declared a national park in 1974. The basic characteristics of this park are densely wooded areas, the Đerdap micro-climate, rich and diverse flaura and fauna, geomorphologic forms, as well as a wealth of cultural and historical monuments dating back to the neolith period. It is a river side, hilly and mountainous park. The area of Đerdapska Klisura comprises three canyons and gorges: Golubacka, Gospođin Vir and the canyons Veliki Kazan and Mali Kazan (big and small chasm, the narrowest and deepest part in the entire course of the river Danube) and three basins: Ljupkovska, Donjomilanovacka and Orsavska. Above these rise the peaks of Miroc, Liskovac and Somrda. These are extraordinarily rich areas and home to various kinds of wild life.

The game preserve in the Đerdap National Park spans an area of 68,608,45 hectares, of which an area of 57,783 hectares is reserved for hunting, including 5,882 hectares of the Danube.

This game preserve is among the richest in Serbia. Long years of work in this area have improved the condition of wild life. Chamois and deer were bred successfully here over a number of years, and now there numbers are satisfactory.

Today there are some 300 wild deer, over 740 roe-bucks, more than 250 wild hogs, over 100 chamois, around 1000 hare and some 250 partridges. Several years were spent in unsuccessful breeding of wild pheasants. There is a mini pheasant farm in the game preserve with around 50 pheasants, from where birds are procured for the hunting area. There is a sufficient population of migratory wild birds, wild ducks, wild geese and pigeons. There are also a large number of

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carnivorous animals. There are around 50 wolves, which are significant predators. There is a large population of foxes, wild cats, minks and skunks. It was believed until now that the lynx cat inhabits only the area of Veliki and Mali ? but they are to be found almost all over the park.

The bear is a constant inhabitant of the National Park, their numbers vary with seasons, and most often bears are seen in the area bordering with Srbijasume in parts of the game preserve which are around Homolje.

Wild Deer

According to estimates there are around 300 wild deer in the game preserve. The spring count revealed that their numbers increased during the previous two years. Our effort is to increase the wild deer population to 500 animals, which was the case when the game preserve was included in the National Park. The problem in increasing the wild deer population is linked with the food available in the preserve. Since the preserve is mostly wooded (70%), and there are very few meadows and little arable land (10%), it is necessary that all arable land and pastures are adapted into a constant source of food for wild life. Most of the pastures and meadows are in private ownership. Due to the disintegration of villages and the immigration of local population to cities, majority of estates have been abandoned, thus the already small number of pastures has reduced even further. The quality of meadows had deteriorated, which are over grown with weeds and bushes which the deer do not like to eat. The few portions of arable land which are farmed have become an attraction to the deer resulting in constant conflicts and law suits with local population. The oak tree forests which presented a large feeding ground have also deteriorated, leaving the forest floor devoid of grass which is more suitable for wild hog than deer. Thus the deer have been literally forced out of their natural habitat.

The appearance of the wolf as a predator in the game preserve was accepted as a positive element because it was expected that the predator will eliminate weak animals which are unable to survive. The growing number of wolves however had a very negative influence on the deer population. Large packs attack and kill grown deer, and have been known to massacre young animals in some years. Added to these factors poaching has brought the deer population in a very delicate condition.

The number of deer is being kept stable with huge efforts. Their feeding grounds are being expanded to parts of the preserve where until now there were no deer. This has led to a mild increase in their population.

Roe-buck

Some 740 roe-bucks of all age groups are currently being kept in the game preserve. Ten years ago there was a sudden fall in the number of roe-bucks. The fall was due to the appearance of wolves and constant poaching. All this had negative effects on the roe-buck population, so hunting was brought to a minimum. In this case also wolves were expected to act as cleaners in the forest, but their effect was detrimental. Intensification of work in the preserve, increase in pasture land has led to a mild rise in the roe-buck population.

Prize game is very rare but this is not due to the terrain or cold winters. A bad gene pool or bad selection left to wolves or both factors have led to the dearth of prize game among roe-bucks.

The project of providing fresh genes to the roe-buck population is under way. Roe bucks from Vojvodina have been introduced and results will depend on several factors.

Wild hogs

There are 250 wild hogs in the game preserve. In certain years the number is sufficient but in other years there is a population explosion. In these periods the damage done by hogs is enormous and costs more than the income realised through hunting. As the wild hog does not need a specific habitat and does not depend on natural food sources, it happens that in years when acorns are in plenty the hog population leaves the preserve during the autumn and winter seasons, to return in spring for birthing. Such conditions reduce hunting and leave the preserve with too few hogs. In the years when there are less acorns and forest fruits, the pressure on agriculture is enormous. The custom of local people of planting only corn worsens the damage. Inadequate regulations concerning protection of farms and the fact that law always favours the side that has suffered damage has led to a situation where certain farmers plant corn where it is easily accessible to hogs, so that they can earn from money paid in damages, which is far larger in amount than the value of the corn.

The negative effect of the departure of villagers on arable land has a positive influence on the population of hogs. Orchards which are still fruitful have in general become overgrown and present an ideal habitat for the wild hogs. The situation is similar with unkempt meadows, where wild hogs find ideal shelter among bushes. This leads to bad hunting conditions. Hogs move around very little, and the chances of hunting them are small. In cases when hunting is possible the animals killed are young and very rarely prize game. The number of hunting dogs is also decreasing which makes the hunt very difficult. Increasing the hog population in good hunting conditions could make the game preserve very popular but the threat of disease among hogs stands contrary to that effort.

Chamois

The population of chamois in the national park in the area of Veliki and Mali Strbac was introduced in 1963 and 1964. It developed very successfully and there were more than 300 chamois in the preserve at one point. Since during that period the preserve was not equipped to handle such a large number of chamois they began to migrate to other preserves. Lack of shelter and poaching led to the disappearance of chamois outside the area of Veliki and Mali Strbac. The appearance of the lynx cat in the area combined with poaching reduced the number of chamois to a minimum, which is less than the number of animals originally introduced to the preserve. Strengthening security, ban on hunting, and better food sources brought a mild increase in the chamois population, but it never reached the level on which it was in the best period. The chamois is very attractive game for hunters, and since at present conditions are not suitable for hunting it has been decided to breed chamois within the preserve areas they inhabited earlier. This could also provide animals to other parts of Serbia suitable for their habitation.

Hare

The Đerdap game preserve is a hilly and mountainous one, so that hare does not have an ideal environment; despite that the population of 1000 hares has remained stable. Hunting has been according to planned levels for many years. The hare is not attractive game in the preserve. Commercial hunters are not interested in hares.

Partridge

The number of partridges has been stable at 250 for years. Partridge hunting has not been possible for years and because of difficult hunting conditions it is not attractive game. The partridge population is dependent on the plots of land where wheat has been planted, and their numbers literally depend upon the number of these plots. Bad conditions in winter and a large number of predators have kept the number of partridges at the same level during the course of several years.

Migratory birds

Wild duck is the only interesting game in the preserve among migratory birds. The wild duck is hunted mainly during the winter months when the ducks come to the Danube before migration. There is also a constant population of ducks which nest on the banks of the Danube and their numbers have been relatively stable. The migratory ducks vary in number depending on weather conditions. The appearance of the bird flu has led to a sudden loss of interest in bird hunting.

Carnivorous animals

The most attractive of carnivorous game is definitely the wolf. The number of wolves in the national park is growing and now there are 50 of them. The wolf population is not distributed in the same way permanently in the preserve and depends upon availability of food in neighbouring preserves and weather conditions. Hunting varies from one to two animals annually and there are more cases when animals were killed accidentally and not as a result of organised hunt. The big problem with wolves is the damage they make to domestic cattle. Damage done to wild animals is enormous, and since hunting has not led to a decrease in the number of wolves, the wolf has become a huge problem in the game preserve.

Foxes are also found here and at present are hunted only during hunts for other game, primarily the hog.

Bear

The bear is a constant inhabitant of the preserve. The bear is a protected species so bear hunts are not organised and there is no damage done by bears. The number of bears is constantly monitored.

The variety of terrain, woods and the fund of game available give special value to this preserve. There is accommodation for hunters in different parts of the preserve. A frequent problem which has persisted for quite a long time is the growing population of hogs who do great damage to agricultural farms. Hunting of hogs should be increased and local residents must be instructed to strengthen security. Another big problem is poaching which has alarming consequences and needs to be dealt with by authorities in charge.

Generally speaking, the condition and quality of wild life in the national park is satisfactory. A small amount of investment in food resources could improve the condition of wild life.

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FROM THE PRINCIPLE OF SUSTAINABILITY TO THE SUSTAINABLE FOREST MANAGEMENT PLANNING

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Abstract: *Sustainability of production or production sustainability was emphasised as a problem in the middle of the 19th century, and today it is equally topical. The problem of ensuring the production sustainability, sustainability of yield and revenue is one of the basic reasons of forest management. Nowadays sustainable forest management requires the changes in the approach to planning and it should take into account the following:*

- forest management should be performed in a manner close to natural processes, and the task of the planned management systems is to conserve and not to endanger the forest natural renewability, quality and biological stability;

- to conserve biodiversity and landscape values;

- forest management objective is not only to produce wood, but also the other forest products, as well as to make a profit from ecological, aesthetical, cultural and spiritual forest functions;

- multiple criteria should be applied to assess the efficiency of forest ecosystems, how much of each resource is produced (individually) and sustainably; in planning, the current biological, social and ecological risk factors should be considered;

- increase the efforts on linking forestry with other economic activities;

- take care of the inter-generation and intra-generation equality;

- take care of the equal status of all forests in the strategic interests.

Key words: Sustainability, management, biodiversity, inter-generation end intra-generation equality

1. INTRODUCTION

Forest management planning, as the scientific field and the practical forestry discipline, has always had a permanent task to apply such management systems in planning that ensure the optimal realisation of the goals of forest management.

The goals of forest management have evolved during the last two centuries from the sustainable production, yield and income in wood to multifunctional utilisation of total forest potentials in forest areas, implied in the globally accepted definition of sustainable forest management.

2. METHOD

On the whole, the method applied in this study is complex. In addition to the basic synthetic and analytic survey of the main indicators, in the quantitative and qualitative senses within the basic structure of this paper, the historical survey (method) is also applied aiming at the better

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understanding of the planned attitude to the forest, from the origins of forest management planning to the present day.

3. FOREST STATUS AND UTILISATION FROM THE ASPECT OF THE SUSTAINABILITY PRINCIPLE

As early as the 18th century, some authors tried to define the task of forest management planning. Hartig 1791 defined the basic objectives as the "assessment of the present and future yield of wood in the forests". The main objective of the forest management planning is sustainable yield, based on wood supply and increment, which will guarantee wood supply also to the future generations (Hartig 1804, after Medarević M. 2006).

The basic principles of the first definitions of forest management planning were not changed for many years – almost a century and a half.

Forests on Mt. Tara were felled from time immemorial, i.e. at first only for the domestic use exclusively, then in the seventies and eighties of the 19th century also for speculation (Vasić, 1908). Thus K. Đorđević 1886 spent quite a long time on Tara and, as an experienced taxator, he collected the necessary data based on which he prepared a framework management plan for the Ministry, with the plans of forest harvesting and regeneration in a narrow part of Tara (Vladisavljević, 1991). This is also indicated by the data on the beginning of the planned harvesting of beech forests in Serbia.

Baranac (1933) in his account on beech forests in the Municipality Paraćin, reports that in 1910 a greater part of the area was rented to the Serbian Glass Factory in Paraćin in concession for exploitation, for the purposes of the factory.

A part of FA Paraćin in the complex Južni Kučaj, by the Decision of the Minister of National Economy in 1909, was leased to Resavski Rudnici (2224 ha), and 3187 ha to the state-owned Senjski Rudnik, for mine timber.

In his paper "Management planning of coppice forests for coal production in South Serbia", Petrović (1933) reports that "charcoal production has considerable significance. There are many oak and beech coppice forests which are the result of coal production. In these forests, coal was produced for domestic purposes and also for export to Greece".

Such practice of forest management planning and forest harvesting continued for a long time, both in the world and in our country. This can be seen in some theoretical explanations in the middle of the last century. Miletić (1953) reports that "forest management in a wider sense includes two great areas: production and utilisation. Production should be as high as possible – maximal, continuous and economic, and utilisation should be continuous and rational.

In a wider sense, the objectives of forest management planning are:

- maximal and continuous production of forest products necessary to the social community, by applying the professional regeneration and intensive stand tending, and by soil conservation and increase of soil productivity, based on the silvicultural and economically assessed inventory;
- continuous and rational utilisation and maximal improvement of the general status;
- timely harmonisation of production and consumption.

From the sixties to the present day in our country, the theoretical bases and the methodology of forest management planning have been gradually created and developed, enabling the multifunctional approach (Jović 1968, Medarević, 1983, 1992).

Today, the framework model of sustainable and rational forest management and management planning is based on the generally accepted definition of sustainable management which means "the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems" (Helsinki, 1993).

Based on the above definition, sustainable forest management required the changes in the approach to planning, which in the aim of multipurpose utilisation of forest resources, insists on the more comprehensive approach, using the information base in which the dominant idea is the ecological dimension of a forest as an ecosystem.

Forest management planning as a system should take into account the following principles:

1. ***Forest management should be performed in a way close to natural processes, and the objective of the planned management systems is to conserve and not to endanger its natural renewability, quality and biological stability.***

Of the total area of forests and other wooded land (2,349,720 ha) high forests cover 44.1%, coppice forests 45.5%, poplar plantations 1.6%, and thickets and brushland 8.8%. Average volume is 110 m^3/ha, and average current volume increment is 3.05 m^3/ha. The site production potential is used 75% in high forests and 40% in coppice forests (Medarević *et al.*, 2004, 2005, 2006).

To increase the natural renewability, and also the quality and bioecological stability, the two strategic aims are:

- Conversion of coppice forests (as much as possible) into high forests;
- Increase the forest cover percentage (by supporting the natural regeneration processes) and create forest reserves in quality.

2. ***To conserve natural diversity and landscape values.***

In Serbia, in the previous cycles of forest inventories at the stand level, more than 80 tree species were recorded, 15 of which are allochthonous species. Of the total number of species, 38 are on the list of endangered, rare and relic species, i.e.: 12 are rare and endangered, 5 are rare tree species, 9 are relic, 6 endemic and 6 at risk. According to IUCN categorisation, the species are critically endangered if there is an extremely high risk of their extinction in the wild in near future.

Of the total number of species identified in Serbia, only 11 species can be harvested for commercial purposes (felling) without major risk. They are: beech, sessile oak, Turkey oak, common hornbeam, common oak, Hungarian oak, silver lime, black locust, Austrian pine, spruce, and fir.

Landscape diversity in Serbia and forest diversity, as one of the landscape structures, is sufficiently shown by the number of the singled out ecological units (160) and forest types (200). From the aspect of property, the landscapes are more fragmented in private forests.

In Serbia, the dominant forms are modified natural forests (> 90% of the total area).

The estimated biomass of the dead wood in our forests accounts for about 16% of the living wood biomass (estimated minimum is about 2%).

Altogether 1017 ha of seed stands were singled out to ensure the reproduction of individual species and the gene pool protection of the most valuable forest communities (Medarević *et al.*, 2006).

3. ***Forest management objective is not only to produce wood, but also other forest products, as well as to make profit from ecological, aesthetic, cultural and spiritual forest functions.***

In Serbia, compared to the Pan European criteria and indicators, the utilisation of basic forest products is insufficient and non-rational.

• The quantity of allowable cut at the annual level accounts for 1% of the volume and 40% of the volume increment (Table 1) which can be evaluated as the adequate percentages, taking into account the present state of the forests.

Table 1. Quantity of allowable cut in Serbia

Districts	Average yield in wood 1992 – 2002 m3	Percentage of technique %	Annual afforestation ha
Serbia	2 649 510	40	3 473
Central Serbia	1 849 254	34	2 208
Vojvodina	640 039	54	1.066
Kosovo	267 680	-	348

• The estimated energy potential of cordwood, forest waste, and sawdust in Serbia is 22.9 GJ/per year (Table 2).

Table 2. The estimated energy potential of cordwood and forest waste (data for state forests only)

Energy potential (GJ/yr)					
		Forest waste			
Category	Cordwood	Stumpwood and roots	Small branchwood	Trimmings and sawdust	Total
Quantity	5 408 648	11 891 620	7 106 546	8 527 855	27 526 020

Source: Kadović, R. *et al.* 2005

Our forest annually absorb from the atmosphere 4,871,250 t of CO_2, the carbon reserves in wood biomass are estimated to 34.23 t/ha.

• Non-wood forest products (other forest products)

The non-wood forest products are presented in Tables 3 and 4.

Table 3. Non-wood forest products (1995)

Product	Quantity	Unit
Juniper	200	ton
Mushrooms	1,395	ton
Gentian	200	kilogram
Blueberry	100	ton
Dog rose	50	ton
Lime and hawthorn (flower)	10	ton
Honey	14,000	ton

Source: TBFRA 2000; 2005

The available data clearly point to the considerable quantities of the produced honey and mushrooms from the forest. The production of juniper, blueberry, dog rose and lime is also significant.

Table 4. Other products from the forest (1995)

Game shooting	Quantity	Unit
Deer	706	head
Roe deer	4.300	head
Wild boar	2.522	head
Hare	129.726	head

Source: TBFRA 2000; 2005

Regarding the present recorded production, the following can be concluded:

– Spontaneous and unplanned, and therefore irrational approach to this aspect of utilisation from the economic aspect;

– More difficult planned approach, taking into account the complex nature of forests and their environments, i.e. the complex nature of flora and fauna individuals, the collection of which does not endanger their survival.

The quantity of killed game, compared to management plans – periodic and annual, is in accordance with the capacity (present census of the main game species).

Taking into account the insufficient density of the populations of individual species and the mediocre quality, the hunting plan most often has a sanitary character.

Total forest area in state ownership, depending on priority functions, is distributed in the following way (Table 5).

Table 5. Distribution of the total area of state forests in Serbia per functional units

Unit	Area		Special forests management objective
	(ha)	%	
10, 11, 12	567,103.15	62.83	Production of technical wood
13,14,15,16,80,92,94	19,322.52	2.14	Game production, rearing and protection
17	1,017.46	0.11	Production of forest seeds
19; 20; 21; 22	17,664.99	1.96	Protection of water (springs)
26; 27, 66	167,320.02	18.54	Protection of soil against erosion
31; 47; 53	1,284.81	0.14	Other protective forests (climate-protection, protection of roads, etc.)
67; 68	74.90	0.01	Protection of natural monuments and belviews
73; 74; 75; 77; 78;	4,396.33	0.49	Intensive recreation
55; 56; 57; 81; 99	42,117.01	4.67	Protection of the sites of rare, endangered and valuable forest and other ecosystems
70,79;83	971.53	0.10	Nature and landscape protection and conservation (especially valuable natural ambiance units)
71; 86; 84	2,165.21	0.24	Scientific research/ protection of areas of completely conserved nature
95; 97	679,30	0.08	Protection of nature and ambiance within natural and memorial historical monuments
National Parks	78,419.18	8.69	Conservation of specific and genetic diversity, tourism and recreation
	824,117.23	100.00	

4. Apply multiple criteria to assess the efficacy of forest ecosystems, how much of each resource is produced (individually) and sustainably.

The criteria and indicators of sustainable forest management adopted at the global level have been implemented in forestry practice in the last years. The more real possibility of their application is in the part which refers to forest and wood as the voluminous resources (probably because of the previous planned utilisation and monitoring), and much less to other forest products (food, medicinal plants, seeds, etc.).

5. In planning, take into account the existing biological, social and ecological risk factors

In the regular procedure and process of planning the sustainable production, protection and utilisation of forest ecosystems, there are clearly defined restricting and endangering factors – risk factors. We shall mention some of these effects.

The risk factors in real planning and sustainable utilisation of forest ecosystems are: forest dying, forest fires, hurricane winds and storms, climate changes, contaminated air, as well as soil acidification. Here are some characteristic examples.

Defoliation in Serbia (2003) accounts for 36.6% on conifers and 21.4%.on broadleaves

Annual burnt forest area in Serbia in the period 1990 – 2004 was 2,324 ha. Onl y in 2000, in forest enterprise Vranje, the burned forest area was about 1,000 ha, and 13,018 ha burned in the same year in Serbia. Forest fires in the period 1990 -2004 emitted the following quantities of gases: 148.420 t CO_2, 380 t CH_4, 3.500 t CO and 60 t NO (Kadović *et al.* 2005).

Hurricane wind in 1998 in the area of Gornji Srem caused the damage of 109,000 m^3.

The deposition of heavy metals in forest lands contributes to soil acidification (Kadović R., Knežević M. 2002.).

In the last 35 years (1971 – 2005) annual temperature in the area of Serbia has increased by the intensity higher than 2.5°C per 100 years. At the same time, the intensity of summer rainfall reduction, per series in the last 34 - 40 years, accounted for more than 20% of the normal per 50 years.

6. Increase the efforts on linking forestry with other economic activities.

In present conditions, modern planning should have the character of integrated planning at different levels. The following should be born in mind:

- intersectoral dependence and relation (mutual or complementary goals and interests, and sometimes potential conflicts);
- interplan dependence and relation (e.g. spatial plans, sector plans, strategies, policies, etc.);
- legal harmonisation.

7. Take care of the inter-generation and intra-generation equality

The principle of inter-generation equality includes the transfer of the capital heritage to the following generation, or the equivalent or the greatre assets in the form of natural resources, in this case forests (taking into account the fact that the population density permanently increases).

The realisation of long-term strategic goals of planning the sustainable forest utilisation includes the following:

1. enhancement of forest status: conversion of coppice forests into high forests, by the reclamation of degraded forests into high-production stands, reclamation of coppice forests of poor quality and reconstruction of inferior quality degraded high forests into better quality, support of the natural regeneration, and forest protection;
2. increase the area under forest (by re/afforestation) in accordance with the global spatial zoning and categorisation. In this sense, re/afforestation till 2015 should cover 1,000 km^2
3. meeting the appropriate ecological, economic and social functions;
4. inter-generation and intra-generation equality in the multipurpose forest utilisation.

As for the sustainable management of hunting grounds, the basic goals are:

1. significantly increase the population densities of small and big game,
2. improve the structure (sex and age) of the big game population and the trophy quality,
3. conserve the rare and endangered species of game for hunting and other fauna.

Regarding the protected areas, the basic goals include the protection of the following:

1. exceptional and unique nature (significant for scientific, cultural - education, recreation, etc. purposes);
2. characteristic representatives of individual ecosystems and outstanding bio-geographic areas, i.e. individual landscape types;

3. natural landscapes, ambiances around the cultural - historical monuments;
4. the goals of biodiversity protection include also the conservation of genetic, specific and ecosystem biodiversity.

By the realisation of the above mentioned goals, the principle stated in the point (7) will be ensured and warranted for the most part.

The principle of intra-generation equality includes the impartial distribution of the natural and man-made capital, which ensures the satisfaction of basic human needs in all social groups.

The appreciation of this principle permanently emphasises the limited property right to the forest as the natural resource.

8. Take care about the equal status of all forests regarding strategic interests.

Forest is a natural system whose characteristics and complexity condition, inter alia, the moderate and balanced utilisation and the high level of precaution and awareness regarding the need of its conservation. It should always be borne in mind that a forest is always a forest, disregarding the anthropocentric aspects of its value.

Regarding the above mentioned goals, all forests should have the same status because it is the question of strategic interests which are, by their rank, above the other interests (if they are really defined).

4. CONCLUSION

Regarding the origin and the initial steps of forest management planning, it can be concluded that the basic principle based on which forest management planning was "created" was the principle of sustainability, and it included the sustainable production, yield and income in wood.

This principle existed for a long time within the mono-functional approach to planning, till the sixties of the last century because, according to Miletić (1953), forest management includes two major areas: production and utilisation, in which production (wood) should be as high as possible – maximal, stable and economic, and utilisation should be permanent and rational.

Nowadays, the sustainability, or the planning of the sustainable forest management refers to:

- conservation of biodiversity;
- conservation of productivity, natural renewability, vitality and stability;
- meeting the ecological, economic and social forest functions;
- harmonisation of utilisation, while not endangering the other ecosystems and the environment in general;
- inter-generation and intra-generation equality regarding the disposal of the forests as the resources.

And, before all and after all, a forest is a forest, conditionally renewable and as healthy as we keep it healthy regardless of the utilisation.

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SECTION 7

SIGNIFICANCE OF URBAN FORESTS AND OTHER GREENSPACE CATEGORIES FOR URBAN AND INDUSTRIAL SETTLEMENT ENVIRONMENTS

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Abstract: *Taking into account the actual state of the environment of large, especially industrial towns, and starting from the fact that ecosystems are among the most stable terrestrial ecosystems, they should get a much higher significance in the narrow and wider urban zones.*

The study of forest ecosystems surrounding the major cities, in many countries in the world has been singled out as a special scientific discipline - urban forestry. Urban forestry includes the activities related to the city core, suburban areas and the zone of interaction with rural areas.

This paper presents a detailed list of goods and benefits of urban forests and other greenspace categories in towns (with special reference to Belgrade, the capital of Serbia), their multi-functionality realised through the sustainable - integral forestry and ecosystem management by the above principles.

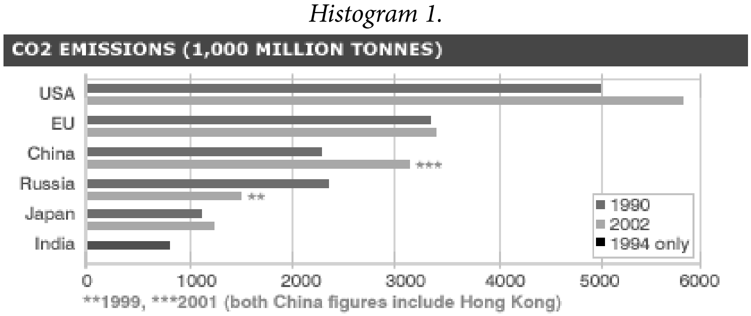
Key words: urban forests, urban greenspaces, multi-functional valorisation, sustainable - integrated ecosystem management

1. INTRODUCTION

It is a fact that we are facing the increasing hazard to all elements of the environment and natural ecosystem in general, as the consequence of the race for the profit, disregarding the ecological consequences. The previous method of "depleting the nature" questions the man's survival and the life on our planet in general.

The Histogram shows that in the emissions of harmful gases (CO2), the leading countries are USA, EU countries, China, Russia, Japan, India, Brazil, etc.

Histogram 1.



It is estimated that in 2020 the developing countries will produce ½ of the total quantity of carbon compounds, while western countries, thanks to their transfer to "pure" technologies, will account for only 25% of the atmospheric pollution.

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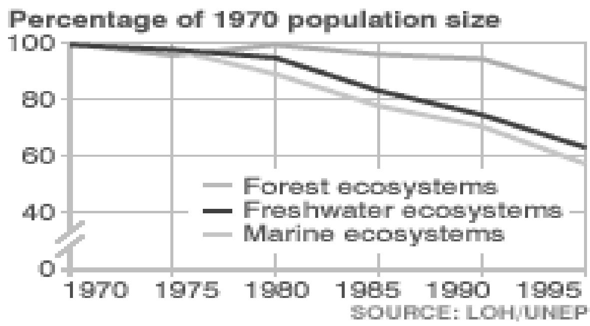
The effects of global warming and climate changes are obvious. From 1850 to date, the diameter of alpine glaciers has been halved. The sea temperature changes so rapidly that it endangers the survival of the entire ecosystems. It is predicted that the temperatures on the earth till 2100 will increase by 6 degrees, mean sea level will rise for minimum 14cm, and according to some prognoses even up to 80 cm, which will endanger many towns and islands.

Acid rains cause water and soil acidification, damage the forests on large areas, they have destructive effect on other materials including the priceless values - buildings, sculptures, paintings and others which are a part of the world's cultural heritage. Before reaching the ground, sulphur dioxide (SO_2), nitrogen oxides (NOx) and their compounds contribute markedly to the environmental degradation in various ways, by harmful impacts on human health. Also: CH_4, HFC, PFC, SF_6 …, nuclear power plants and nuclear waste, and other types of radiation. The data of the World Health Organisation show that each year about 3 million people on our planet die from asthma, pulmonary tumours and cardiovascular diseases, and their "silent killers" are the above and numerous other harmful compounds. Our planet is slowly but surely changing into a huge gas chamber!

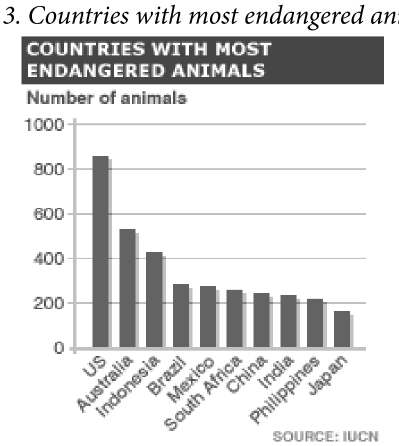
As the consequence of climate changes, while in one part of the planet the rains and large-scale floods are increasingly more frequent, on the other part of the globe the drought causes desertification leading to increasing range of desert landscapes. The problem of safe and pure drinking water is becoming increasingly topical!

Millions of animal and plant species could become extinct due to climate changes. According to the evolution model for Europe, Russia to Caucasus, Mexico, South Africa, Australia and C. Brazil (with the greatest number of species), as per different scenarios, 9-31% (15-37%; 21-51%) of species will be extinct.

Histogram 2. Reduction of biodiversity in forest and aquatic ecosystems compared to 1970



Histogram 3. Countries with most endangered animal species



2. ACTIVITIES OF THE INTERNATIONAL COMMUNITY ON THE CONSERVATION OF ENVIRONMENTAL QUALITY

To hinder, or at least to mitigate, the environment degradation processes and the overharvesting of the renewable and non-renewable natural resources, the international community, led by the United Nations, has adopted numerous Declarations, Resolutions and other regulations which are binding for the signatory states.

Some of the most significant international regulations on environmental protection, the necessity of biodiversity conservation and sustainable development in all spheres of human activities, are:

Stockholm Declaration adopted at the United Nations Conference on the Human Environment in June 1972. Its basic principles are the following:

"Man is both creature and moulder of his environment, which gives him physical sustenance and affords him the opportunity for intellectual, moral, social and spiritual growth. In the long and tortuous evolution of the human race on this planet a stage has been reached when, through the rapid acceleration of science and technology, man has acquired the power to transform his environment in countless ways and on an unprecedented scale"…

"The protection and improvement of the human environment is a major issue which affects the well-being of peoples and economic development throughout the world"...

"Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations".

"The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations".

"The capacity of the earth to produce vital renewable resources must be maintained and, wherever practicable, restored or improved".

"Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperilled by a combination of adverse factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development".

"The non-renewable resources of the earth must be employed in such a way as to guard against the danger of their future exhaustion and to ensure that benefits from such employment are shared by all mankind".

"Resources should be made available to preserve and improve the environment, taking into account the circumstances and particular requirements of developing countries and any costs which may emanate- from their incorporating environmental safeguards into their development planning and the need for making available to them, upon their request, additional international technical and financial assistance for this purpose".

The Resolution of the UN General Assembly, held in December 1972, defines the need for urgent and efficient implementation by the Governments and international communities of the predicted measures for environmental conservation and enhancement, for the benefit of present and future generations. By this Resolution, the Board of the United Nations Environment Programme (UNEP) was established with the following basic functions and responsibilities*:*

- enhancement of international cooperation in the field of environment,
- recommendation, when needed, of the policy to ensure the general political guidelines and coordination programme in the field of environment within the UN system, with taxatively numbered commitments,

- establishment of the fund for environment which will be used for financing the programmes of enhancement environment.

Nairobi Declaration, May 1982, concluded that the principles and the Action Plan adopted in the Stockholm Declaration (1972) have only been partially implemented, because Action Plant has not had sufficient impact on the international community as a whole. So, it is declared that: *"Some uncontrolled and unplanned human activities cause an increasing deterioration of the environment. Deforestation, soil and water degradation and desertification are reaching alarming proportions, and seriously endanger the living conditions in large parts of the world. Diseases associated with adverse environmental conditions continue to cause human misery. Changes in the atmosphere, such as those in the ozone layer, the increasing concentration of carbon dioxide, and acid rain - pollution of the seas and inland waters, careless use and disposal of hazardous substances and the extinction of animal and plant species constitute further grave threats to the human environment. The states should promote the progressive development of environmental law, including conventions and agreements, and expand co-operation in scientific research and environmental management...".*

World Charter for Nature was adopted in October 1982. The basic principles of this Charter are:

-Mankind is a part of nature and life depends on the uninterrupted functioning of natural systems, which ensure the supply of energy and nutrients.

- Every form of life is unique, warranting respect regardless of its worth to man and, to accord other organisms such recognition, man must be guided by a moral code of action.

- The degradation of natural systems owing to excessive consumption and misuse of natural resources, as well as to fauna to establish an economic order among peoples and among States, leads to the breakdown of economical, social and political framework of civilization.

- Nature shall be respected and its essential processes shall not be impaired.

- The genetic viability on the earth shall not he compromised, the population levels of all life forms, wild and domesticated, must be at least sufficient for their survival, and to this end necessary habitats shall be safeguarded.

- All areas of the earth both land and sea, shall be subject to these principles conservation, special protection shall be given to unique areas, to representative sample of all the different types of ecosystems and to the habitats of rare or endangered species

- Ecosystems and organisms as well as the land, marine and atmospheric resources that are unutilized by man, shall be managed to achieve and maintain optimum sustainable productivity, but not in such a way as to endanger the integrity of those other ecosystems or species with which they coexist.

- Natural resources shall not be wasted, but used with a restraint appropriate to the principles set forth in the present Charter, in accordance with the following rules:

- Living resources shall not be utilized in excess of their natural capacity for regeneration.

- The productivity of soils shall be maintained or enhanced through measures which safeguard their long-term fertility and the process of organic decomposition, and prevent erosion and all other forms of degradation.

- Agriculture, grazing, forestry and fisheries practices shall be adapted to the natural characteristics and constraints of given areas.

- Areas degraded by human activities shall be rehabilitated for purposes in Accord with their natural potential and compatible with the well being of affected populations.

The Rio Declaration on Environment and Development, adopted twenty years after the seminal Stockholm Declaration, confirms its basic principles:

- Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

- In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

- The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

- To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

- In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities.

- *National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution...*

Agenda 21, adopted at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, contains the global programme of actions for sustainable development and it is one of the most comprehensive and the most significant documents on the environment in development. Agenda 21 addresses the pressing problems of today and also aims at preparing the world for the challenges of the next century. It reflects a global consensus and political commitment on development and environment cooperation. The broadest public participation and the active involvement of the non-governmental organizations and other groups should also be encouraged.

At the **Earth Summit + 5** UN General Assembly Special Session (UNGASS) held in New York in June 1997 to review the results of implementing Agenda 21, it was concluded that, in most countries, very small progress was achieved. The main recommendation of this Conference is that it is necessary to adopt the **strategy of sustainable development** which would promote the commitment for the concept of sustainable development in all countries of the world. It launched a new global partnership for sustainable development - a partnership that respects the indivisibility of environmental protection and the development process. The implementation of Agenda 21 in a comprehensive manner remains vitally important and is more urgent now than ever.

At the global level, renewable resources, in particular fresh water, forests, topsoil and marine fish stocks, continue to be used at rates beyond their viable rates of regeneration. As a result, increasing levels of pollution threaten to exceed the capacity of the global environment to absorb them, increasing the potential obstacles to economic and social development in developing countries.

The most significant provisions of Agenda 21 refer directly or indirectly to forests as irreplaceable natural ecosystems in the conservation of environment quality.

Lisbon Resolution – L2. The third Ministerial Conference on the Protection of Forests in Europe, held in 1998 in Lisbon, Portugal, presented the Pan European criteria, indicators and guidelines for sustainable forest management, recalling the Resolutions adopted at the Ministerial Conference in Helsinki, Resolution H1 "General Guidelines for the Sustainable Management of Forests in Europe" and Resolution H2 "General Guidelines for the Conservation of the Biodiversity of European Forests". Six basic criteria for sustainable forest management were adopted from "Pan European criteria and indicators for sustainable forest management (Annex 1), as well as the indicators for international reports and development and the use of national indicators. Also, "Pan-European operational level guidelines for sustainable forest management" (Annex 2), were adopted as the framework recommendations for sustainable forests management for practical purposes.

The European Commission for development, in the Chapter "Sustainable management of forest resources", inter alia states that: … "Forests provide numerous direct and indirect benefits for the society. Direct benefits refer to the cultivation of the renewable quantities of plants and animals. Indirect benefits include water and soil conservation, carbon storage, climate regulation and protection of biodiversity. Forests are also important for the developing countries, providing the means for both the rural and industrial economies. Forest and forest resources can fulfil, now and in future, numerous ecological, economic and social functions, at the local, national and global levels."

3. SIGNIFICANCE OF FOREST ECOSYSTEMS FOR URBAN ENVIRONMENT

In addition to the above Resolutions, Declarations, principles and statements referring to environmental protection and sustainable utilisation of natural resources, especially forest ecosystems, bearing in mind the significance of forest ecosystems located in the surroundings of major cities, urban forestry as a special scientific discipline, has been established in many countries of the world Practically, this is the field that integrates different profiles of professions: engineers of forestry, landscape architecture, horticulture, spatial planning, etc. Urban forestry deals with the cultivation and management of urban forests. for their present and potential contribution to the environmental, social, and economic well-being of urban society. In the centre of urban forestry is the tree and forest management, and it is closely related to landscape architecture and park management. In its broader sense, urban forestry embraces the problems of water, wildlife habitats, outdoor recreation opportunities, landscape design, recycling of municipal wastes, tree care and the production of wood as a raw material.

Urban forestry includes the activities which refer to urban core, suburban areas and the zone of interactions with rural parts. The activities differ depending on the zone in which they are applied (Kuchelmeister, G., Braatz, S.). In central parts, the activities are limited, while in suburban areas the possibilities are wider.

The planting of trees in human settlements, and as an integral part of landscape architecture, is not new; it has its roots in ancient Chinese, western Asian and Greek civilizations (Jellicoe, 1985). A number of ancient cities had highly developed parks, gardens and other green spaces - the most notable being Babylon, the origin of gardens, dating back more than 3,000 years. The Assyrian civilization and, much later, the classical Persian and Greek civilizations in the fifth century BC, also had such a tradition, based on culture and religion. In Europe in the seventeenth and eighteenth centuries, urban - public and crown forests were managed for recreational hunting. Later, the elite developed urban gardens and parks as visual amenities in many European cities, particularly Italy, France, Austria and England. The plantings subsequently spread to colonies in Africa and Asia. Spanish colonization introduced into Latin America the concepts of interior patios in houses and public plazas in urban centres. Throughout history, the planting and management of trees and forests has been based much more on aesthetic and spiritual values than on economic benefits.

4. FUNCTIONS AND VALUES OF FOREST ECOSYSTEMS IN URBAN ENVIRONMENTS

As a result of the predominance of concrete buildings, asphalt and metal as well as the concentration of transport systems and industrial activities in and around urban areas, the median temperature is higher (the "heat island" effect), the air is drier and often polluted, rainfall is less efficiently absorbed and the noise is generally more intensive than in a rural setting.

A list of well-beings and benefits from forests and other categories of urban green spaces is impressive:

Environmental protection

Cleaning the air

- Trees very effectively absorbs gaseous pollutants, including carbon monoxide, sulphur dioxide, nitrogen oxides, ozone and hydrocarbons.
- Trees intercept dust: a belt of trees measuring 30 meters in width has been found to intercept almost all dust in the air.
- Keller (1979), researched and proved by measurements an 85 percent reduction in lead behind a shelter-belt of trees.
- Trees also neutralise and almost completely absorb disagreeable odours, by replacing them with more pleasing scents
- Trees also help to increase the relative humidity of urban air through evapotranspiration.

Modifying temperature extremes

- Trees, shrubs and other vegetation help to control temperature extremes in urban environments by modifying solar radiation.
- The shade of one large tree may reduce the temperature of a given building to the same extent as would 15 air conditioners (4220 kJ), in a similar but unshaded building.
- Energy saving through tree-planting around houses ranges from 10 to 50 percent for cooling and from 4 to 22 percent for heating (NAA/ISA, 1991).

Noise reduction

- Excessive noise levels in most major cities contribute to both physical and psychological damage. Trees can help both by absorbing noise such as that produced by the heavy traffic and numerous activities in urban areas.

Water use, reuse and conservation

- The systems of parks and forests can integrate stabilization ponds (reservoirs) for waste water treatment.
- The greatest potential of wastewater reuse is in arid zones in developing countries (Braatz, 1994; Kuchelmeister, 1998).
- Protection of suburban and rural areas which are the sources of water for urban areas should be integrated in city plans.

Soil conservation

- Trees and forests are a means of soil conservation, preventing landslides in fragile ecosystems with steep terrain, little vegetation and harsh seasonal rains, and thus protecting people's lives and homes.

Biodiversity conservation

- Biodiversity of green areas has a vital role in urban biodiversity. Suburban wetlands can be some of the most productive natural ecosystems and can provide important habitats for fauna. Incorporating green areas in networks will improve biological conservation and biodiversity; greenbelts and greenways (linear parks) can serve as biological corridors (IUCN, 1994).

Social Benefits

Improving the aesthetic quality of urban areas includes the aesthetic and recreational value of trees, forests and parks. Trees fulfil certain psychological, social and cultural needs of the urban dweller (Dwyer, Schroeder and Gobster, 1991). They play a very important social role in easing tensions and improving psychological health; people simply feel better living around trees. One study has demonstrated that hospital patients placed in rooms with windows facing trees heal faster and require shorter hospital stays (Ulrich, 1990). When appropriately selected and placed, trees are effective in screening out undesirable views and ensuring privacy while permitting free visual access to the rest of the landscape. Parks provide easily accessible recreational opportunities for people.

Health – Health Parks and green areas provide opportunities for healthy physical activity. In addition, the passive benefit to physical and mental health of an urban landscape with trees has been documented in industrialized countries (Ulrich, 1984); enjoyment of green areas may help people to relax or may give them fresh energy. Improving air quality through the planting of vegetation certainly has an impact on health, with such obvious benefits as decreased incidence of respiratory illnesses.

One of the greatest problems of modern man is stress. Stress and the diseases caused by stress have dramatically increased among the adult population, but also among children in western societies. Significant funds are earmarked for medical treatments of the diseases which are the consequence of stress life, particularly various types of depressions, fears and panics, insomnia, etc. The results of the study (Stigsdotter, U.A, 2003) in which 953 randomly selected persons in nine Swedish cities answered a questionnaire concerning their health and utilisation of open green spaces in the city and its surroundings, show that green areas can have a significant positive effect on health. Statistically significant correlation was shown between utilisation urban green spaces and reduction of stress and diseases which are the consequence of stress, regardless of the age, sex and socio-economic status. The study results suggest that the persons who visit green urban areas more frequently, are much less susceptible to diseases related to stress. From the beginning of the eighties, the increasing number of researches indicate that nature can bring a rapid and very visible recovery to the persons under stress (Kaplan & Talbot, 1983; Ulrich, 1984, 2001; Herzog et al. 1997).

Urban forests can also contribute to food security and quality.

Employment – Tree planting, afforestation, and especially urban agroforestry provide employment which may be especially important in poorer cities. In the economically developed countries this can be a significant business.

Food production – Urban agriculture is common in many cities in Asia, Latin America and Africa (Yeung, 1987; Sanyal, 1985; Streiffeler, 1987; Ninez, 1985; Skinner, 1981). Fruit-trees are often an important component of urban home gardens. Trees are planted to supplement fuelwood and to provide raw materials for handicrafts

Urban agroforestry is very important as a means of improvement of livelihoods of the poorest part of the population.

Fuelwood provides between 25 and 90 percent of urban household energy supplies; it is particularly important as a source of energy in smaller urban centres in developing countries (Kuchelmeister, 1998). Under favourable circumstances, fuelwood from non-rural forests and agroforestry systems can contribute significantly to fuelwood supply.

Education and scientific research – visitor information centres should be established in urban forests, botanical gardens, zoos, and other forms of nature and they can inform people about flora and fauna. They can also serve for scientific research

Recreation – Urban forests greatly enhance outdoor recreation. Lower income residents frequent city parks, wealthier citizens reach more distant recreation sites. Therefore, forests and green areas must be within an affordable travelling distance and must have the amenities that people desire.

Increase of economic power of the cities and value of real estate - House prices increase in the vicinity of trees, for example up to 5% in Hong Kong (Webb, 1998) and in the Finland (Tyrvainen, 1999) and up to 18% in the United States (Morales, Micha and Weber, 1983).

In Singapore and Kuala Lumpur a tree-rich urban landscape is an important attraction for new businesses and investors (Kuchelmeister, 1998).

In addition to aesthetical and ecological values, trees can contribute to meeting the energy needs, but also the foodstuff, particularly of the poorest part of the population.

Urban forests unite people to work together for the benefit of the community and improve the quality of the environment at the local level (NUFU, 1998).

There are very topical researches which quantify the benefits of urban forests and other categories of urban green spaces. Through the ***benefit*** (energy saving, air quality improvement, carbon dioxide sequestration, prevention of torrents and erosion, reduced consumption of thermo-electric power, etc.) - ***cost*** (planting, pruning, waste disposal, maintenance of infrastructure, supervision, administration) ***analysis***, the developed models assess the monetary value of the benefits achieved by energy saving, reduction of air pollution, improvement of water quality and aesthetic values.

Their economic value is especially quantified: they are evaluated as the parts of the value of urban property; based on the cost of the establishment, maintenance, and establishment of new plantations; values as products – timber, fuelwood etc.; through the increase of the property and real estate values, because trees can increase the property value by average 20% (Payne, 1975).

They are also evaluated by the profitability of urban forest land. Land use for wood production is considered unprofitable compared to other land uses (recreation, semi-natural areas, etc.). As natural areas in the urban environment are developed, the remaining forest land and urban forests can be increasingly higher evaluated as natural resources which protect water quality, as wildlife sites and for recreation. It is an interesting fact that many members of the community are unaware of the economic value of trees if they are not evaluated as timber.

For this reason also, it is necessary to calculate the economic value of trees (e.g. if somebody's tree is damaged of cut). In this aim, there are legal instruments such as insurance (e.g. in USA, per one tree, up to $500), damage compensation, etc.

For this reason, numerous scientific-research and professional institutions in the world deal with the above topics: In USA: Center for Urban Forestry Research, Urban Forest Ecosystems Institute, USDA Forest Service – Recreation, Wilderness, Urban Forests and Demographic Trends Research Group, Athenes, USA, American Forests: Urban Forest – each second year organise National Urban Forest Conference, Urban Forest Ecosystem Resources, California Urban Forests Council, Ontario Urban Forest Council, and all other states in USA, Community and Urban Forestry, Montrose District of the Colorado State – Forest Service, Urban Forestry, Atlanta, Oregon Department of Forestry – Urban Forestry, Centre for urban Forestry Studies; In Canada: Urban Forest Center, Toronto, Urban Forest and Urban Wildlife Habitats, Winnipeg, Manitoba; In Australia: Urban Forest Biodiversity Programme; South African Republic: Urban Forest, Johannesburg, etc.

As auxiliary instruments, there are numerous programmes which are powerful tools for the work in this sphere. One of them is produced by the American Forests – Environmental System Research Institute, under the title "CITY green" – GIS application for land use policy and planning. The software includes and controls a complex statistical analysis of the ecosystem and environment. As the result of the analysis, it produces readily understandable maps, reports and economic calculations depending on the specific site conditions. The analysis includes, inter alia: precipitation, air quality, energy savings accumulated during summer, balance of carbon and oxygen, growth and development of trees. Both the wide region studies can be performed and the small-scale details, ecological maps, models of future growth and development, readily understandable presentations, automatic reports and summary reviews of key facts. It can be used by spatial planners, foresters, urban foresters, landscape architects, or other ecologists. It is suitable for different ecological studies and city planning.

A research of the effects of urban forests on human health and environment started in 1978, within USDA Forest Service, USA. The research of urban forests included the measurement of the effects and the value of urban trees – the effect of forests on air and water quality, energy consumption, urban climate, ultraviolet radiation, etc. The data from the whole world were collected to be able to understand the urban forest ecosystems and a valuable database was established. The scientists from numerous institutions of the USA cooperate in this long-term project of ecosystem research. As a result, a computer model was developed to quantify urban forest effects (UFORE). This research included also the appropriate maps, 30 m resolution.

All the above mentioned acts, Declarations, Resolutions, as well as the activities of the institutions in this field, are based on three basic principles: sustainable – integrated forestry, ecosystem management and multifunctional valorisation of forest resources.

5. SOME RESULTS OF THE PROJECT "INTEGRATED VALORISATION OF FOREST RESOURCES IN BELGRADE"

Taking into account the actual state of the environment in the two-million Belgrade, and starting from the fact that forest ecosystems are among the most stable terrestrial ecosystems, they should get a much greater significance in both the narrower and the wider city zone.

The common attitude that forests are exclusively intended for production should be replaced, and forest ecosystems in the vicinity of major cities and settlements should be given the new functional priorities in harmony with the principles of sustainable development, protection and enhancement of environmental quality.

In our country, forests as an ecosystem, have a significant place in the Law on Environmental Protection and in numerous ratified international Resolutions, and other legal documents which have to be adhered to.

In the past, in forest management plans which prescribed the method of forest management, the priority was given to forest economic harvesting, as the raw material potential for wood production, while the multiple use forest functions were mainly declaratively stated. The survey of the valid forest management plans for urban forests indicates that such attitudes have been significantly changed and that today the priority is given to protection functions, primarily soil conservation, but also to recreation functions in urban forests.

To assess the state of forest ecosystems in the surroundings of Belgrade and to improve their functionality, the Secretariat for Environmental Protection has appointed the Institute of Forestry for the research on the Project "Integrated valorisation of forest resources in Belgrade". The Project is realised through three stages: urban forests, suburban forests and forests for special intensions. The final goal of the project is the integrated management of the green aspect of biodiversity.

Total forest area in Belgrade amounts to 35,887 ha of which state forest are on 20,064 ha, while private forests cover 15,823 ha

The percentage of forest cover in Belgrade region accounts for 11.1 %, and forest area per capita is 0.025 ha. Pursuant to valid standards, “the minimal optimal value” of forest area per capita amounts to 0.33 ha. The degree of forest cover in Serbia is about 27% and the planned forest cover percentage in Serbia is about 40%. The previous Spatial Plan of Belgrade defines that Belgrade should have minimum 90,000 ha under forests, therefore another 34,049 ha of forests are still necessary for Belgrade to reach the present level of forest cover in Serbia.

This disadvantage is somewhat compensated by the green spaces of other categories on the total area of 2,258 hectares:

- Parks and squares 393 ha
- Greenery in residential areas 1,078 ha
- Greenery along the roads 175 ha
- Banks, riparian area, V. Ratno Ostrvo 226 ha
- Protection belts 36 ha
- Greenery of special category 350 ha
- Trees in tree rows 67,063 trees.

The research performed in the framework of stage I (urban forests), enables the identification of new multiple-use functional priorities pursuant to the principles sustainable development, biodiversity protection, and environmental protection and enhancement.

This stage included: integrated valorisation of forest resources and their functions, study and identification of the priority multiple-use functions of forest resources in Belgrade, determination of the percentage of each function ranked by priorities, the valorisation of the beneficial ecological forest functions as the contribution to the creation of a healthier environment, the determination of the basic principles of forest management. In this aim, it was proposed to extend the forest ecosystem by afforestation, the development of urban forestry was stimulated and the development of the new and the improvement of the existing anthropogenically established forests of different purposes was proposed.

Localities of urban forests studied in Stage I:

Locality	Area (ha)
Košutnjak and Topčider	262.71
Forests around Beli Dvor and Stari Dvor at Dedinje	75.00
Park of Beli Dvor and Stari Dvor at Dedinje	25.00
Miljakovačka forest	155.95
Banjička Šuma	41.59
Zvezdarska Šuma	129.00
Stepin Lug – Baba Velka – Torlak – Jajinci	491.72
Makiš	380.22
Ada Ciganlija	92.65
Forests along the highway Belgrade–Zagreb, to Surčin	159.74
Total	1,813.58

Contents of research

Experience in the field of multifunctional valorisation of forest resources in urban environments:

- Foreign experience
- Domestic experience

Analysis of the state:

- Basic data on forest resources in Belgrade;
- Ecological - environmental conditions;

- Vegetation and floristic research;

- Comparative research of the development of individual autochthonous and allochthonous species of flora;

- Classification of Belgrade forest resources: age, structure, productivity, conservation degree.

Selection and mapping of biotopes within the study of forest resources, according to the determined methodology.

Valorisation of the functionality:

- Comparison of the existing and selection of the most favourable method of valorisation of the functionality of forest resources for Belgrade;

- Valorisation of the existing functionality of Belgrade forest resources.

Valorisation of functionality of Belgrade urban forests

In the aim of estimating the relative values of the main functions of urban state forests in Belgrade administrative area, multiple-use forest functions are classified into three groups:

- production function
- protection-regulatory function
- socio-cultural function.

The results of the valorisation of functionality of urban forests in Belgrade show that all forests reach their maximum in the socio-cultural function (recreation, education, science) or protection-regulatory function (protection of soil, water, urban microclimate and air quality, nature protection), and each complex has its own priorities. This was the base for the proposal of the new approach to the integrated valorisation of the functions of Belgrade forest resources, the proposal of the priority functions of Belgrade forest resources, in harmony with their position in the urban entities, and the proposal of measures for the achievement of the dominant and secondary functions of forest resources.

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Table 1 Estimate of relative values of the main functions of urban state forests in the administrative area of Belgrade

LOCALITY	MAIN FOREST FUNCTION (%)													
	PRODUCTION				%	PROTECTION-REGULATION			%	SOCIO-CULTURAL			%	100%
	Wood production	Production of safe food and medicinal plants	Game rearing and hunting	Production of other products (forest seed, peat, etc.)		Soil protection	Water protection	Micro-climate and air quality		Recreation	Nature protection and spatial management	Education		
Košutnjak	10	3	-	2	15	10	10	10	30	30	15	10	55	100
Topčider	-	-	-	5	5	10	10	20	40	30	20	5	55	100
Miljakovačka forest	10	2	-	2	14	10	10	20	40	28	13	5	46	100
Jajinci	5	3	-	5	13	10	10	16	36	15	30	6	51	100
Torlak	15	5	-	-	20	20	10	20	50	5	20	5	30	100
Stepin Lug	10	5	-	5	20	20	10	15	45	20	10	5	35	100
Zvezdara	5	-	-	-	5	10	10	25	45	25	20	5	50	100
Banjička Šuma	5	-	-	5	10	5	5	30	40	15	25	10	50	100
Makiš	5	3	-	5	13	10	20	17	47	20	15	5	40	100
Ada Ciganlija	5	3	-	2	10	10	15	10	35	40	10	5	55	100
Forest along the highway BG-ZG to Surčin	10	-	-	-	10	5	5	50	60	10	15	5	30	100

**In stage I of the Project, the production function "game rearing and hunting" is not planned in Belgrade urban forests. The rearing of game and other fauna is presented through the socio-cultural function: "nature protection and spatial management", and it was also included in the proposal for the establishment of photo-safari, "wildlife park", etc. at the appropriate localities.*

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TAXONOMIC ANALYSIS OF FLORA, ASH DISPOSAL AREA AND COAL SLAG IN THE IMMEDIATE SURROUNDING AREA OF THE POWER PLANTS "NICOLA TESLA" A AND B

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Abstract: *Besides Pancevo, Bor, Kostolac, Lazarevac and Kosovska Mitrovica, Obrenovac is one of the most polluted urban areas not only in Serbia but in the Balkans. The main reason for this is the fact that one of the most powerful electro-energetic plants in the Balkans (the power plants 'Nicola Tesla A and B') is situated near the town of Obrenovac. In the process of producing electricity, the burning of the low-calorie lignite from Kolubara coal mines also produces millions of tons of ash and areopollutants which pollute the air, soil, water and food in the wide area thus endangering the health of people but also of other living creatures and ecosystems. Sanitation, revitalization and re-cultivation of this type of soil is extremely difficult, complex and expensive and for a long time it has been one of the top priority tasks in the area of applied ecology in Serbia.*

This elaborate analysis contains taxonomic analysis of flora, ash disposal area and coal slag in the immediate surrounding area of the power plants 'Nicola Tesla A and B' with the analysis of life forms and ecological bioindicating indexes. In the researched area 144 species (specimens) have been collected from their domicile, then determined and housed at herbarium divided into 112 genera and 42 families.

By following and analyzing life forms and the ecological indexes for species given in the table 1. it is easy to make a mixture of seed and seedlings which will be sown and planted in the soil, substrate such as ash because those are the plants which during their evolution have adapted to the given abiotic factors: humidity, acidity, the amount of nitrogen, light, temperature.

Key words: *ash disposal areas, revitalization and re-cultivation, life forms, ecological indexes, abiotic factor.*

1. INTRODUCTION

In the area of the Obrenovac Municipality, at the right side of River Sava, 30-50km upstream from Belgrade, the two largest power plants in Yugoslavia were built (Power Plant Nicola Tesla - A and B) named after our great scientist Nicola Tesla, of total capacity amounting to 2890MW. PPNT - A with 6 blocks has overall capacity of 1650MW photo 12; PPNT - B with two blocks has total installed capacity amounting to 1240MW, which makes half of the power plant capacity in the Electric Power Industry of Serbia and quarter of the power plant capacity in Yugoslav Electric Power Industry.

With respect to its dimensions and "production" of the ashes, disposal site of the PP "Nicola Tesla"- A is among the largest in the world. In all installed capacities of the Power Plant "Nicola Tesla" 25.000.000 tons of coal is transported annually, which is thereafter disposed on the disposal site or sent in transporters directly to boiler bunkers, wherefrom after passing through mills, it is

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put in boiler fireboxes in the form of powder. In PP "Nicola Tesla" boilers in Obrenovac, in case of full exploitation of capacities, 90.000 tons of coal is burned daily for producing 60.000.000 KWh. Both power plants (A a nd B) s pend 3.500 t ons of coal in a n hour, for the maximum production. By burning low calorie lignite in the Power Plant "Nicola Tesla" and disposing waste gases through electro-filters, 17.000 tons of ashes and slag is separated daily.

Since the ashes completely destroys vegetation cover, and having regard that the ashes are sterile substrate or a substrate containing some elements of mineral nutrients frequently represented in the forms inaccessible to plants, this should be reconsidered and a great attention should be dedicated to the selection of plant species tolerant/adaptable to the conditions of growth in ashes and slag disposal sites and the selection of land improvement measures that allow growth and de velopment o f t hese p lants, a nd t herefore t he p lants w hich sp ontaneously o ccupy t hese areas as pioneering species.

In order to make any kind of revitalization - sp ontaneous or combined with woods, successful through an thropogenic me asures, i t is necess ary t o have in min d existin g eco logical, vegetation and floristic potential available at the territory in question.

2. TAXONOMIC ANALYSIS OF FLORA IN INVESTIGATED AREA

In t he habitations o f the in vestigated a rea, 144 s pecies c lassified in to 112 genera a nd 42 families were found and arranged in the herbarium.

The most f requent fa milies a re *Poaceae* with 15 g enera a nd 22 sp ecies, *Fabaceae* wi th 12 genera and 20 species, *Asteraceae* with 19 genera and 20 species, *Brassicaceae* with 6 genera and 8 species, *Lamiaceae* with 5 genera and 6 species, *Borraginaceae* with 5 genera and 5 species and *Euphorbiaceae* with 1 genus and 5 species. The plants from these 7 families participate with over 59% in the vegetation of ashes and slag disposal area, as well as in cubes and humid fields in the immediate surroundings of disposal areas.

The most tolerant plants that thrive in ashes belong to grasses, leguminosis and weeds.

Table 1. Overview of flora at ashes and slag disposal area and immediate surroundings of PPNT A and B with life form and ecological index labels

FAMILIES AND SPECIES	LIFE FORM	ECOLOGICAL INDICES				
		H	A	N	L	T
Poaceae						
Agropyron repens (L.) Beauv	a Mes-Meg G rhiz caesp	3	3	4	4	3
Alopecurus pratensis L.	a Meg-Alt H caesp	3	3	4	3	3
Arrhenatherum elatius (L.) Beauv	a Meg-Alt H caesp	3	3	4	3	3
Bromus arvensis L.	a Mes-Meg T scap	2	3	3	3	4
Bromus mollis L.	a Mi-Meg T scap	3	3	3	3	3
Bromus sterilis L.	a Mes-Meg T caesp	2	3	4	3	3
Bromus tectorum L.	a Mes-Meg T scap	1	3	3	4	4
Calamagrostis epigeios (L.) Roth	a Meg-Alt H caesp	3	3	3	3	3
Dactylis glomerata L.	a Meg H scap	3	3	4	3	3
Festuca arundinaceae Schreb.	a Meg-Alt H caesp	4	4	3	4	3
Festuca pratensis Huds.	a Meg H caesp	3	3	3	4	3
Festuca rubra L.	a Mes Meg H caesp	3	3	3	3	3
Holcus lanatus L.	a Meg H caesp	3	3	3	4	3
Hordeum vulgare L. (6.)	a Mes-Meg T caesp					
Hordeum murinum L.	a Mes-Meg H caesp	2	3	4	4	4
Lolium perenne L.	a Mes H caesp	3	3	4	4	3

FAMILIES AND SPECIES	LIFE FORM	ECOLOGICAL INDICES				
		H	A	N	L	T
Phragmites communis Trin.	Alt emer Hyd G rhiz	5	3	3	3	3
Phleum pratense L.	a Mes-Meg H caesp	3	3	3	3	3
Poa pratensis subsp. angustifolia	a Meg- H caesp	1	3	2	4	3
Poa pratensis subsp. pratensis L.	a Mes-Meg H caesp	3	3	3	3	3
Sorghum halepense (L.) Pers.	a-aut Meg-Alt G rhiz caesp	2	2	3	4	5
Vulpia myuros (L.) Gmel.	a Mes-Meg T caesp	1	2	2	4	4
Fabaceae						
Amorpha fruticosa L.	fo dec Mi P caesp	4	3	3	3	4
Astragalus onobrychis L. (1.)	Mes Ch suff rept	5	2	4	3	-
Coronila varia L.	a Meg H scap	2	4	2	3	3
Genista tinctoria L.	a Mes-Meg Ch suffr	3	2	2	4	3
Gleditchia triacanthos L.	fo dec Mes P scap					
Glycyrrhiza echinata L.	a Meg-Alt G rad scap	3	3	2	4	4
Lathyrus pratensis L.	a Meg H scap	3	3	3	3	3
Lathyrus tuberosus L.	a Meg G tub rept	2	4	2	4	4
Lotus corniculatus L.	a Mes H scap	2	4	3	4	3
Medicago lupulina L.	a Mes T scap/a H scap	2	4	3	3	4
Medicago sativa L.	a Mes-Meg H scap	2	4	3	4	4
Melilotus alba Medic.	a Meg T scap/a H scap bienn	2	3	2	4	3
Melilotus officinalis (L.) Pallas.	a Meg- Alt H scap bienn	2	4	3	4	3
Trifolium campestre Schreb.	a Mes T scap	2	3	2	4	3
Trifolium pratense L.	a Mes H scap	3	3	3	3	3
Trifolium repens L.	a Mi H rept	3	3	4	4	3
Vicia cracca L.	a Meg-Alt H scap/SH herb	3	3	3	4	3
Vicia incana Gou.	a Mes Alt H scap	1	4	3	3	4
Vicia sativa L. a	Mes-Meg T scap/ ST herb	3	3	3	3	4
Vicia tetrasperma (L.) Schreb.	Mes ST herb	3	3	2	3	3
Asteraceae						
Achillea millefolium L.	a Meg H scap	2	3	3	4	3
Artemisia absinthium L.	Meg Ch suff caesp	2	3	4	5	4
Carduus acanthoides L.	a Meg Alt H csap bienn	2	3	4	4	4
Centaurium umbellatum Gilip.	a Mes Meg t ros a H ros bienn	3	3	3	4	3
Cirsium arvense (L.) Scop.	a Meg-Alt G rad scap	3	3	4	4	4
Conyza canadensis (L.) Cronq.	a Meg-Alt T scap	2	3	3	4	4
Crepis foetida ssp. rhoeadifolia (Bieb.) Celak	a Mes-Meg T scap/a H scap bienn	2	3	3	4	4
Erigeron canadensis L.	a Meg-Alt T scap	2	3	3	4	4
Eupatorium cannabinum L.	a Meg-Alt H scap	4	4	3	3	3
Inula britanica L.	a Mes-Meg H scap	4	4	3	3	4
Leucanthemum vulgare Lam.	v-aut Mes-Meg H scap	3	3	3	4	4
Matricara inodora L.	a Mes-Meg T scap/a H scap bienn	3	3	3	3	3
Matricaria chamomile L.	a Mi -Mes T scap	3	3	3	4	4
Picris hieracioides L.	a Meg- Alt H scap bienn/a H scap	2	4	3	4	3
Senecio vernalis W.Etk.	v Mes-Meg T scap	2	3	3	4	4
Sonchus arvensis L.	a Meg-Alt H scap	3	3	4	3	3
Stenactis annua (L.) Nees.	a-aut Mes-Meg T scap/H scap bienn	3	3	3	4	4
Tragopogon dubius Scop.	a Mes-Meg H scap bienn	2	3	3	4	4
Tussilago farfara L.	v Mi-Mes G rhiz	3	4	3	4	3
Xanthium strumarium L.	a Meg-Alt T scap	3	3	4	4	5

FAMILIES AND SPECIES	LIFE FORM	ECOLOGICAL INDICES				
		H	A	N	L	T
Brassicaceae						
Alyssum alyssoides (L.) L.	v Mi-Mes T scap	2	4	1	4	4
Capsella bursa pastoris (L.) Med.	v-aut Mi-Meg T ros/ H ros bienn	2	3	3	4	3
Lepidium draba L.	v-a Mes-Meg H scap	2	4	3	3	4
Lepidium campestre (L.) R. Br.	a Meg T scap/a H scap bienn	2	4	3	4	3
Rorippa austriaca (Crantz.) Bess.	a Meg H scap	4	3	3	3	4
Rorippa sylvestris (L.) Bess.	a Mi-Mes H scap	4	4	3	4	4
Sinapis arvensis L.	v-a Mes-Meg T scap	3	4	3	4	3
Sisymbrium orientale L.	a Meg T scap/a H scap bienn	2	3	3	4	4
Lamiaceae						
Glechoma hederacea L.	a Mes-Meg H rept/ Ch herb rept	3	3	3	3	3
Lamium purpureum L.	v Mi-Mes T scap	3	4	4	4	3
Mentha longifolia (L.) Huds.	a Mes-Meg H scap	4	4	4	3	3
Salvia verticilata L.	a Mes-Meg H scap					
Salvia nemorosa L.	a Mes-Meg H scap					
Scutellaria hastifolia L.	a Mi-Meg G rhiz scap	4	3	3	3	4
Borraginaceae						
Anchusa officinalis L.	a Meg H scap bienn/a H scap	2	3	3	4	4
Echium vulgare L.	a Mes-Alt H scap bienn/a H scap	1	3	3	5	4
Cynoglossum hungaricum Sm.	a Mes Meg H scap bienn					
Myosotis arvensis (L.) Hill.	a Mes H scap bienn/a T scap	2	3	3	3	2
Symphytum officinale L.	a Mes-Meg H scap	4	3	4	3	2
Euphorbiaceae						
Euphorbia esula L.	a Meg-Alt H scap	3	4	3	4	3
Euphorbia cyparissias L.	a Mes-Meg H scap	2	3	2	4	3
Euphorbia helioscopia L.	a Mi-Meg T scap	3	3	4	4	4
Euphorbia palustris L.	a Meg-Alt G rad caesp	4	4	3	3	4
Euphorbia salicifolia Host.	a Meg H scap	3	3	3	3	4
Ranunculaceae						
Clematis integrifolia L.	a Mes-Meg H scap	3	4	3	3	4
Consolida regalis S. F. Gray	a Mes-Meg T scap	2	4	3	3	4
Ranunculus arvensis L.	a Mes-Meg T scap-semiros	2	4	3	3	4
Ranunculus repens L.	a Mes-Meg H rept	4	3	3	3	3
Rosaceae						
Crategus monogyna Jacq.	fo dec NP caesp	3	4	2	4	3
Potentilla argentea L.	a Mes-Meg H scap	1	3	1	4	3
Potentilla reptans L.	a Mi-Mes H rept	3	3	2	3	3
Rubus caesius L.	fo dec NP rept	4	3	5	3	4
Salicaceae						
Populus alba L.	fo dec Mes P scap	3	4	3	4	5
Populus tremula L.	fo dec Mes P scap	3	3	3	4	3
Salix alba L.	fo dec Mes P scap	4	4	4	3	3
Salix cinerea L.	fo dec NP caesp	5	3	2	4	3
Scrophulariaceae						
Veronica agrestis L.	v-aut Mi-Mes T scap	3	3	4	3	3
Verbascum phlomoides L.	a Meg-Alt H ros bienn	2	4	3	4	5
Linaria vulgaris Mill.	a-aut Mes-Meg H scap	3	3	3	4	3
Caryophyllaceae						

FAMILIES AND SPECIES	LIFE FORM	ECOLOGICAL INDICES				
		H	A	N	L	T
Lychnis flos- cuculi L.	a Meg H scap	4	3	4	3	3
Melandrium album (Mill.) Garcke.	a Meg H scap bienn/a H scap	2	3	4	4	3
Stellaria media (L.) Vill.	v-aut Mi T rept	3	3	4	3	3
Cyperaceae						
Carex hirta L.	a Mes-Meg G rhiz caesp	3	3	3	3	3
Carex vulpina L.	a Meg H caesp	5	3	2	4	4
Carex riparia Curt.	a Meg emer Hyd G rhiz	5	4	3	4	4
Geraniaceae						
Erodium ciconium (L.) L' Herit	v-a Mi-Meg T scap/a H scap bienn	2	3	3	4	4
Erodium cicutarium (L.) L' Herit	v-a Mi-Mes T semiros-scap	2	3	3	4	3
Geranium dissectum L.	a Mi-Meg T scap	2	3	3	4	4
Malvaceae						
Abutilon teophrasti Medic.	a-aut Meg T scap	2	3	3	4	5
Althea officinalis L.	a Meg-Alt H scap	3	3	3	4	5
Malva sylvestris L.	a Meg-Alt H scap bienn/a H scap	2	3	4	4	4
Polygonaceae						
Bilderdykia convolvulus (L.) Dum.	a Mes-Meg T scap/SH herb	3	3	3	3	3
Rumex acetosella L.	a Mes-Meg H scap	2	1	2	5	3
Rumex crispus L.	a Meg-Alt H scap	3	3	3	4	3
Cornaceae						
Cornus mas L.	fo dec Mi P caesp/Mi P scap	3	4	3	3	4
Cornus sanguinea L.	fo dec Mi P caesp	3	4	3	3	3
Rubiaceae						
Cruciata glabra (L.) Ehrend	v-a Mi-Mes H scap	2	3	2	4	3
Galium aparinae L.	Mes-Meg ST herb	3	3	5	3	4
Aceraceae						
Acer negundo L.	fo dec Mes P scap	3	3	3	3	4
Amaranthaceae						
Amaranthus retroflexus L.	a Mes-Alt T scap	2	3	4	4	4
Apiaceae						
Daucus carota L.	a eg H scap/a T scap M	2	3	2	4	3
Aristolochiaceae						
Aristolochia clematitis L.	a Mes-Meg G rad scap	3	4	4	3	4
Asclepiadaceae						
Asclepias syriaca L.	a Meg-Alt G rhiz	2	4	2	3	3
Cannabaceae						
Humulus lupulus L.	a SH herb	4	3	4	3	3
Chenopodiaceae						
Chenopodium album L.	a Meg-Alt T scap	2	3	4	3	3
Convolvulaceae						
Convolvulus arvensis L.	a SG herb rhiz	2	4	3	4	3
Cupressaceae						
Juniperus virginiana	ac semp Mes-P scap					
Dipsacaceae						
Dipsacus laciniatus L.	a Meg-Alt H scap bienn	3	4	4	4	5
Equisetaceae						
Equisetum palustris L.	a Meg G rhiz	4	3	2	4	3
Hypericaceae						

FAMILIES AND SPECIES	LIFE FORM	ECOLOGICAL INDICES				
		H	A	N	L	T
Hypericum perforatum L.	a Mes-Meg H scap	2	3	3	3	3
Iridaceae						
Iris pseudacorus L.	v Meg emer Hyd G rhiz	5	3	4	3	3
Liliaceae						
Ornitogalum umbellatum L.	v Mi G bulb scap	3	4	3	4	4
Lythraceae						
Lythrum salicaria L.	a Meg-Alt H scap	4	3	3	3	3
Oenotheraceae						
Oenothera biennis L.	a Meg-Alt H scap bienn	2	2	2	4	3
Papaveraceae						
Papaver rhoeas L.	a Meg T scap	3	4	3	3	3
Plantaginaceae						
Plantago lanceolata L.	a Mi-Meg H ros	3	3	3	3	3
Resedaceae						
Reseda lutea L.	a Mes-Meg H scap/a T scap	2	4	3	4	4
Solanaceae						
Solanum dulcamara L.	a Meg-Alt S lig	4	3	4	3	3
Spireaceae						
Spirea media Fr. Schm.	fo dec NP caesp	2	3	3	3	3
Tamaricaceae						
Tamarix tetranda	fo dec NP caesp					
Violaceae						
Viola tricolor L.	v-a Mes T scap/H scap bienn	3	3	3	3	3
Musci						
Funaria hygrometrica						
Rumex acetosella L.	a Mes-Meg H scap	2	1	2	5	3
Rumex crispus L.	a Meg-Alt H scap	3	3	3	4	3
Cornaceae						
Cornus mas L.	fo dec Mi P caesp/Mi P scap	3	4	3	3	4
Cornus sanguinea L.	fo dec Mi P caesp	3	4	3	3	3
Rubiaceae						
Cruciata glabra (L.) Ehrend	v-a Mi-Mes H scap	2	3	2	4	3
Galium aparinae L.	Mes-Meg ST herb	3	3	5	3	4
Aceraceae						
Acer negundo L.	fo dec Mes P scap	3	3	3	3	4
Amaranthaceae						
Amaranthus retroflexus L.	a Mes-Alt T scap	2	3	4	4	4
Apiaceae						
Daucus carota L.	a Meg H scap/a T scap	2	3	2	4	3
Aristolochiaceae						
Aristolochia clematitis L.	a Mes-Meg G rad scap	3	4	4	3	4
Asclepiadaceae						
Asclepias syriaca L.	a Meg-Alt G rhiz	2	4	2	3	3
Cannabaceae						
Humulus lupulus L.	a SH herb	4	3	4	3	3
Chenopodiaceae						
Chenopodium album L.	a Meg-Alt T scap	2	3	4	3	3
Convolvulaceae						

FAMILIES AND SPECIES	LIFE FORM	ECOLOGICAL INDICES				
		H	A	N	L	T
Convolvulus arvensis L.	a SG herb rhiz	2	4	3	4	3
Cupressaceae						
Juniperus virginiana	ac semp Mes-P scap					
Dipsacaceae						
Dipsacus laciniatus L.	a Meg-Alt H scap bienn	3	4	4	4	5
Equisetaceae						
Equisetum palustris L.	a Meg G rhiz	4	3	2	4	3
Hypericaceae						
Hypericum perforatum L.	a Mes-Meg H scap	2	3	3	3	3
Iridaceae						
Iris pseudacorus L.	v Meg emer Hyd G rhiz	5	3	4	3	3
Liliaceae						
Ornitogalum umbellatum L.	v Mi G bulb scap	3	4	3	4	4
Lythraceae						
Lythrum salicaria L.	a Meg-Alt H scap	4	3	3	3	3
Oenotheraceae						
Oenothera biennis L.	a Meg-Alt H scap bienn	2	2	2	4	3
Papaveraceae						
Papaver rhoeas L.	a Meg T scap	3	4	3	3	3
Plantaginaceae						
Plantago lanceolata L.	a Mi-Meg H ros	3	3	3	3	3
Resedaceae						
Reseda lutea L.	a Mes-Meg H scap/a T scap	2	4	3	4	4
Solanaceae						
Solanum dulcamara L.	a Meg-Alt S lig	4	3	4	3	3
Spireaceae						
Spirea media Fr. Schm.	fo dec NP caesp	2	3	3	3	3
Tamaricaceae						
Tamarix tetranda	fo dec NP caesp					
Violaceae						
Viola tricolor L.	v-a Mes T scap/H scap bienn	3	3	3	3	3
Musci						
Funaria hygrometrica						

3. LIFE FORM ANALYSIS

Under the life, or ecologic forms we imply organization types of plant and animal species more or less harmonized with ecological conditions of the habitation they occupy as regards their physiological or morphological characteristics. Every life form represents a certain way of adaptability concerning the given conditions of the environment.

It is important to point out that the same species may simultaneously belong to two or a larger number of life forms, depending on the different circumstances affecting its adaptation (**Jankovic M. 1971.**).

The life forms of plants are determined according to the **Ellenberg & M uller-Dambois** classification (1967.), amended and developed according to Mr. **Stevanovic** (1992.) for the territory of Serbia.

Through studying basic life forms of flora in ashes and slag disposal areas of PPNT A and B as well as fills, cubes and humid fields in the immediate surroundings of disposal areas, its hemicryptophyte-therophyte character was determined, where the dominant role belongs to hemicryptophytes (represented with 46,15%) with regard to therophytes (27,27%) out of the total number of species. Other life forms have substantially lower share.

Domination of hemicryptophytes is in line with the leading role of this life form in the overall flora in Serbia. The flora of investigated area is represented with 66 species among which the most represented ones are multi annual dendriforms (H scap) with 35 species, while through elaborating phenologic dynamics it was determined that (a-aesti val) forms which bloom in summertime are predominant, with 62 species. Analysis of the growth form categories showed domination of tall plants, where the most frequent is a transitional group of medium tall Mes-Meg plants, 23 species.

The second most frequent among basic life forms are therophytes with 39 species. Among therophytes, the most represented category is dendriform (T scap) with 32 species, while phenologic analysis shows domination of species blooming in summertime (a) with 27 representatives. Studying of the growth form categories of therophytes showed that transitional group of medium tall Mes-Meg plants dominates with 15 species.

Phanerophyte life form is represented in flora of the investigated area with 14 species (9,79%), all deciduous.

Geophyte life form is represented in flora of the investigated area with 13 species (9,09%), among which, in particular, the most frequently represented are rhizomatous species (7). Studying of phenologic dynamics showed that species blooming in summertime dominate (10).

Other life forms (scandentophytes, chamaephytes and hydrophytes) are substantially less represented in flora of the investigated area.

4. ECOLOGICAL INDICES ANALYSIS

Table 1. defines ecological indices for every determined species.

Ecological conditions in determined phytocenosis can be very easily estimated, if the indicator value of plants present in such phytocenosis was identified.

Ecological indices or indicator values are defined as an ecological optimum of species included in the specific ecological group (**Kojic et al. 1994.**). The scale of indicator values for all factors is in the range from 1 to 5. The only exception is the scale of ecological indices for humidity that varies between 1 and 7, Table - 2. Overview of ecological indices for humidity, acidity, nitrogen quantity, light and temperature is given in Tables 2, 3, 4, 5, 6.

HUMIDITY (V)

Table 2. Overview of ecological indices for humidity

Indicator value	Ecological group of plants	N	%
1	Xerophytes	6	4,44
2	Subxerophytes	48	35,55
3	Submesophytes	57	42,22
4	Mesophytes	18	13,33
5	Hygro-Helophytes	6	4,44
6	Amphibious and floating hydrophytes	/	/
7	Submersed hydrophytes	/	/
TOTAL		135	100

The table shows dominancy of species with ecological index 3 (Sub-mesophytes) and species with ecological index 2 (Subxerophytes), as well as the presence of species with ecological index 1 (Xerophytes), indicating that dry habitations are predominant in the investigated area, which is understandable for ashes and slag as substrates, and fills around disposal sites which are also consisted of the same substrates (ashes and slag).

ACIDITY (A)

Table 3. Overview of ecological indices for land acidity

Indicator value	Ecological group of plants	N	%
1	Acidophilus	1	0,74
2	Transitional group between acidophilus and neutrophilous	5	3,70
3	Neutrophilous	91	67,40
4	Transitional group between neutrophilous and alkaliphilous	38	28,14
5	Alkaliphilous	/	/
TOTAL		135	100

The plants as habitation indicators show that the land of investigated area are of neutral reaction, since neutrophilous plants are prevailing (ecological index 3) with oscillations ranging from mildly acid to mildly alkaline.

NITROGEN QUANTITY (N)

Table 4. Overview of ecological indices for nitrogen quantity in land

Indicator value	Ecological group of plants	N	%
1	Oligotrophic (nitrophobe)	2	1,48
2	Transitional group between oligotrophic and mesotrophic	20	14,81
3	Mesotrophic	80	59,25
4	Transitional group between mesotrophic and eutrophic	31	22,96
5	Eutrophic (nitrophylous)	2	1,48
TOTAL		135	100

Based on this data, it is concluded that the land of investigated area is moderately nitrified, and habitations moderately rich in mineral material prevail, which is a consequence of using nitrogen-based fertilizers on ashes and slag disposal sites.

LIGHT (S)

Table 5. Overview of ecological indices for light

Indicator value	Ecological group of plants	N	%
1	Sciophytes	/	/
2	Transitional group between sciophytes and semi-sciophytes	/	/
3	Semi-sciophytes	61	45,18
4	Transitional group between semi-sciophytes and heliophytes	71	52,59
5	Heliophytes	3	2,22
TOTAL		135	100

The results shown in Table 5 are in accordance with the domination of open habitations in investigated area.

TEMPERATURE (T)

Indicator value	Ecological group of plants	N	%
1	Frigophilous	/	/
2	Transitional group between frigophilous and mesothermic	2	1,49
3	Mesothermic	76	56,71
4	Transitional group between mesothermic and thermophilous	49	36,56
5	Ther mophilous	7	5,22
TOTAL		134	100

Domination of mesothermic plants as well as the high frequency of species with ecological index 4 indicates specificity of microclimate in investigated area.

5. DISCUSSION

Burning coal in power plant boilers creates great quantities of ashes, which are disposed in power plants' nearby surroundings. Disposal of ashes and slag from the PP ''Nicola Tesla" leads to a t otal des truction o f t he v egetation co ver; hence cr eating em pty substra tes f ree o f a ny lif e form. Bearing in mind that strong winds blowing in ashes area may actually create an ecological disaster, there is a need for urgent binding of the surface layer by virtue of plants.

In this work I ha ve, by analyzing life forms and ecological indexes for species that spontaneously a nd t hrough ''supported" r evitalization inha bit t hese enda ngered – de graded a reas, practically sho wn w hich typ e o f p lants ada pted t o a biotic fac tors t hroughout i ts e volutional development: h umidity, acidi ty, ni trogen q uantity, lig ht a nd t emperature. B y r eferring t o a nd analyzing Ta ble-1 with provided analysis of life forms and ecological indices, it is easy to make a mixture of seeds and seedlings to be sowed and planted on the surface, the substrate of which is the ashes.

At the end, we may conclude that all plants growing spontaneously on ashes and slag disposal areas of the PP ''Nicola Tesla" in Obrenovac, may even in a shorter period spread on ashes by means of planting and sowing.

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THE ANTIMICROBIAL ACTIVITY OF FOREST PLANTS TO THE ENVIROMENT

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Abstract: *This paper presents the results of one-year study considering antimicrobial effect of forest species essential oils to the environment. Special attention has been payed to the activity of the species Juniperus communis L. and Mentha longifolia L.& Huds. The aerial parts of plants have been collected in Serbia (Zlatar, Jadovnik, Ozren, Pešterska visoravan, Vidlič and green areas of Belgrade). The samples of essential oils have been obtained from the dried-aerial parts of the plants using hydrodistillation method and analyzed by GC-FID (HP 5890 Series II, HP 5971 MSD, electron impact mode 70). Those analyses have shown that the major constituents of the oils were monoterpene hydrocarbons and phenolic monoterpenes, but the concentration of these compounds have varied greatly among the oils examined. The highest amount of antimicrobial metabolites –essential oils have been detected in the species Juniperus communis L. (up to 3%), and Mentha longifolia (up to 4 %).*

The antimicrobial test results have shown that the forest species essential oils had a great potential of antimicrobial activity against all test-bacterial strains (of the most frequent bacterial species). The antifungal activities of these essential oils have not been recorded (against fungal species Aspergillus niger, Mucor sp., Trichoderma viride and T. harzionum) during this testing.

Key words: aromatic plants, essential oils, antimicrobial activity

1. INTRODUCTION

The plants have a fundamental significance for creating an attitude about the environment. One cannot determine the position of the man in the biosphere and his dependency of it without the knowledge about plants functions. The plants are the basic biologic and ecologic unit which supports the maintenance of the biosphere and also of the human population. Among the numerous functions of the plants, one of the most important is their antimicrobial activity. The antimicrobial activity of the plants is important for the existence of dynamical ecological balance which is the basic condition for the life on the Earth. As a result of this activity, very old and complex plant communities exist at present time. During their long evolution, the plants have created and improved an efficient biological system of antimicrobial activity. This system had supported their survival and also a successful distribution. The capability of antimicrobial protection is a result of the presence of secondary metabolites. Very important are essential oils that exist as secondary metabolites of aromatic plants.

The data from the study of autochton forest's protection had shown that the self-protection is not just the property of the plant species, but also the property of the plant communities (Matović, 1994, 1995, 1995a, 1996, 1997, 1998).

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2. MATERIALS AND METHODS

2.1. Plant material

The aerial parts of plants have been collected in Serbia (Zlatar, Jadovnik, Ozren, Pešterska visoravan, Vidlič and green areas of Belgrade).

2.2. Isolation procedure

Dried aerial parts (200gr) of plants, were subjected to the hydro-distillation of 3h, using an all glass Clevenger-type apparatus, according to the method recommended by the European Pharmacopoeia (European Pharmacopoeia 1983) to produce oil. The oils were dried over anhydrous sodium sulfate and stored in sealed vials at low mtemperature before analysis.

2.3. Gas chromatography

GS analysis were performed using GC-FID (HP 5890 S eries II, HP 5971 MS D, electron impact mode 70). Oven temperature was held at 50^0C for 5 min and then programmed to 240^0C at a rate of 3^0C/min. Detector (FID) temperature was 300^0C and injector temperature was 250^0C at the linear temperature program from 40 - 28 0^0C. The temperature of the transfer line was 280 ^{0}C. The identification of the components have been accomplished by comparation of their retention times and mass specters with the standards. The comparations of the mass specters have also been performed with the data available from the library of the mass specters (Wiley/NBC).

2.4. Antimicrobial activity

Antimicrobial activity of the investigated metabolites was determined by the disc-diffusion method, and by measuring the inhibition zone. The bacterial strains used in this study were: *Agrobacterium tumefaciens*, *Bacillus subtilis*, *Esherichia coli*, *Pseudomonas flurescens*, *Pseudomonas syringae* var. *phaseolicola*; the fungal strains were *Aspergillus niger*, *Mucor sp*., *Trichoderma viride*, *Trichoderma harzionum*. Test concentrations were two dilutions: a) 1g of the plant material in 10 ml of water and b) 1g of the plant material in 20ml of water. Bacteria strains were cultured in the melted feeding agar for 48 hours on 20^0C; fungi were cultured in the dextrose agar for 7 days at the same temperature. The results were compared with bactericide effect of the penicillin or the fungicide effect of the nistatyne.

The experiments have been performed as nine repetitions, and the results were statistically analyzed. The results of this analysis are presented in tables and chromatogram.

3. RESULTS AND DISCUSSION

The character of this paper is partially sinthehyc, and it includes the results of the previous studies. This refers to the numerous studies of the wide area of the former SSSR (Tokin, 1951) and to the results of the Bulgarian scientists research (Koleva, 1980). In the following table 1 are the results of the previous studies of the antimicrobial plant metabolites and also the part of our recent studies results.

The previous data about the effect of antimicrobial metabolites shows that their inhibition time varies from 3 to 25 minutes. Some studies confirms this fact. They show that just one fir during 24h release 30g of volatile compounds to the atmosphere. The fir forest can release 30 kg of the volatile compounds from the surface of 1 ha for the same time period. Dependently of the atmospheric conditions and the time of the year, 1 ha of the pine forest produces 154 to 392g of the fitoncides: the birch forest produces 28 to 310g of the fitoncides.

We can apply this data to the whole planet; we will get a sum about 175 million tones of the essential oils that the planet's vegetation produce per year.

In the *Juniperus communis* essential oil was registered 42 components. From these 42 components, 32 was identified and quantified.

The previous study's data from the tables and graphs shows that the antimicrobial products of *Juniperus communis* have an inhibitory effect which is limited by its chemical content, concentration and by the taxonomical properties of the microorganisms. The antimicrobial effect of *Juniperus communis* essential oil is a result of the high content of α-pinene (30,763%), sabinene (19,372%), p-cymene (0,226%), l-limonene (4,904%) and α-terpinolene (1,318%). The biologically activity of this constituents have already been described by Ross et al. (1980), Adebayo et al. (1989), and Jansen et al. (1987) The content of the *Juniperus communis* essential oil depends of the geological, pedological, climate and other properties of their habitat.

Tab. 1. Microbicidal time of metabolite exposition (min.)

Biljna vrsta	Tokin 1948	Lunc 1974	Koleva 1980	Matović 1994-2005
Cedrus atlantica Manetti	3-5	3	-	3
Larix europea Dc.	-	-	3	3-4
Larix leptolepis G.	-	-	3	-
Pinus ponderosa Doug	-	-	3	-
Platanus orientalis L.	3	-	-	3-4
Thuja gigantea Nutt.	5	-	-	-
Acer negundo. f.variegata L.	4-8	-	-	-
Padus racemosa Gilib.	10	5	-	-
Taxus baccata L.	-	6	-	5
Quercus pubescens Will.	6	6	-	5-7
Quercus robur L.	6	-	-	6
Carpinus betulus L.	7	-	-	6-7
Cornus mas L.	7	-	-	7
Pinus silvestris L.	5-15	-	7-10	6-9
Crataegus monogyna Jac.	8	-	-	8-10
Rubes nigrum L.	10	10	10	9-11
Abies concolor Lind.	-	-	10-12	-
Picea pungens Engel.	-	-	11	-
Juniperus sabina L.	10	10	-	-
Juniperus communis L.	-	-	-	10
Asculus hippocastaneum L.	10	-	-	11
Rhus cotinus L.	11	-	-	10-12
Acar platanaoides L.	-	12	-	12
Laurus nobilis L.	-	15	-	-
Juglans regia L.	18	18	-	17-19
Acer tataricum L.	20	20	-	18-20
Abies alba Mill.	-	-	18-20	19-22
Picea excelsa Link.	-	-	20-25	21
Betula verrucosa Ehrh	20-25	20	-	20-24
Populus alba L.	25	25	-	24

This study established that the milled whole fruits, milled remains of the fruits after the alcohol extraction, milled remains of the fruits after hydro-distillation, water extract of the fruits, milled remains of the fruits after the distillation of the essential oils and essential oil of *Juniperus communis* are inhibiting the growth of *Agrobacterium tumefaciens, Bacillus subtilis and Pseudomonas fluorescens.* An alcohol extract and the milled leaves of *Juniperus communis* are inhibiting the growth of *Agrobacterium tumefaciens* and *Bacillus subtilis.* The intensity of the inhibitory effect is proportional to the concentration of the metabolites.

Tab. 2. Contents of the essential oil in the fruits of Juniperus communis

Poreklo uzorka	% etarskog ulja
Zlatar (Gradina)	3,15
Nova Varoš (Tikva)	2,70
Trnava	2,66
Pešter	2,53
Gradac	2,47
Baljevac	2,40
Sjenica	2,20
Novi Pazar	2,13

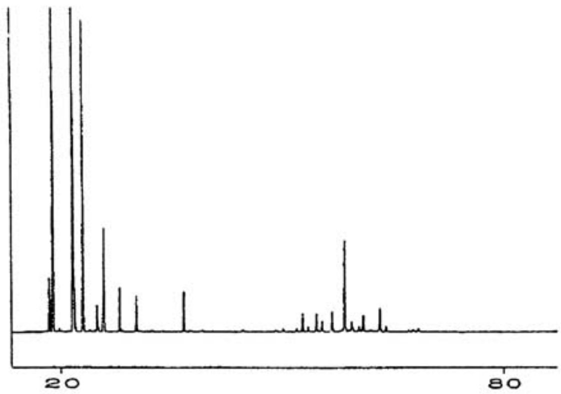
Tab. 3. Juniperi aeterolum – Detailed GS-MS analysis of the essential oil

Br.	RT, min	Naziv jedinjenja	CI*	%	% Rel.
1	14.120	n.i.**		0.091	0.296
2	15.339	n.i.**		0.113	0.367
3	21.506	α-tujen (91)	938	1.465	4.762
4	21.974	α-pinen (93)	942	30.763	100.00
5	22.646	kamfen (97)	954	0.196	0.638
6	23.622	sabinene (91)	976	19.372	62.972
7	23.918	β-pinen (94)	981	2.154	7.002
8	24.163	β-micren (91)	986	16.427	53.399
9	24.865	n.i.**		0.154	0.502
10	25.424	δ-3-karen (90)		0.081	0.262
11	25.597	α-terpinen (97)		0.404	1.314
12	25.739	p-cimen (91)	1020	0.226	0.734
13	26.187	l-limonen (96)	1030	4.904	15.94
14	27.396	γ-terpinen (96)	1057	0.787	2.557
15	27.753	trans-sabinenhidrat (59)		0.178	0.579
16	28.758	α-terpinolen (96)		1.318	4.286
17	28.880	linalol (38)	1092	0.073	0.237
18	32.537	terpinen-4-ol (97)	1175	1.087	3.535
19	32.964	α-terpineol (83)	1185	0.146	0.474
20	34.811	n.i.**		0.234	0.762
21	36.578	n.i.**		0.073	0.238
22	36.752	bornilacetat (99)		0.289	0.939
23	38.759	citronelilacetat (91)	1335	0.171	0.555
24	39.052	neoizotujil alkohol (72)		0.136	0.443
25	39.305	n.i.**		0.081	0.263
26	39.710	nerilacetat (59)	1345	0.117	0.380
27	38.812	α-kubenen (98)	1344	0.609	1.979
28	40.962	α-kopanen (97)	1369	0.645	2.098
29	41.298	(-)-β-elemen (95)		2.063	6.706
30	41.916	epizonaren (94)		0.475	1.543
31	42.494	n.i.**		0.154	0.500
32	42.677	γ-elemen (98)	1425	3.278	10.655
33	42.923	β-farnezen (90)		1.002	3.259
34	43.361	junipen (45)		0.067	0.219
35	43.799	α-humulen (98)	1437	1.421	4.618
36	44.280	n.i.**		0.167	0.544
37	44.649	epi-bicikloseskvifelandren (93)		6.376	20.725
38	45.008	α-muurolen (92)		0.264	0.858
39	45.570	γ-kadinen (98)	1510	0.345	1.121
40	45.683	δ-kadinen (99)	1524	1.282	4.168
41	46.449	n.i.**		0.121	0.394
42	47.655	n.i.**		0.690	2.243

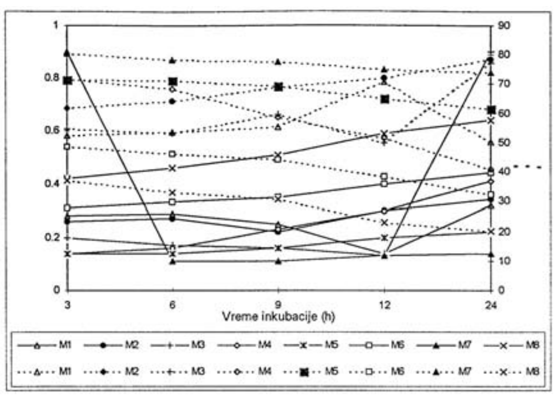
Because of the *Juniperus communis* antimicrobial effect and attractive forms, the designers of the cities green areas should consider the higher frequency of this plant.

During the study of the aromatic plants of Serbia, a special attention was dedicated to *Mentha longifolia*. The flora of Serbia has ten species of genus *Mentha* (fam. *Lamiaceae*).

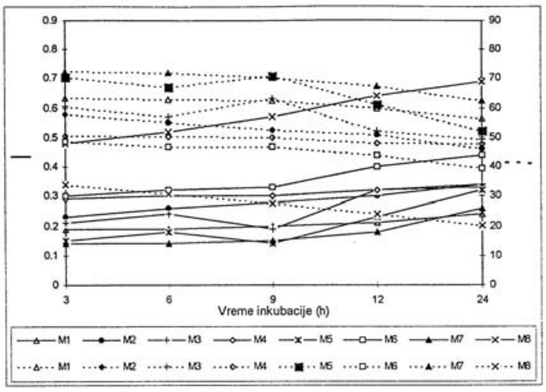
Graph. 1. Juniperi aeterolum- The chromatogram of the essential oil



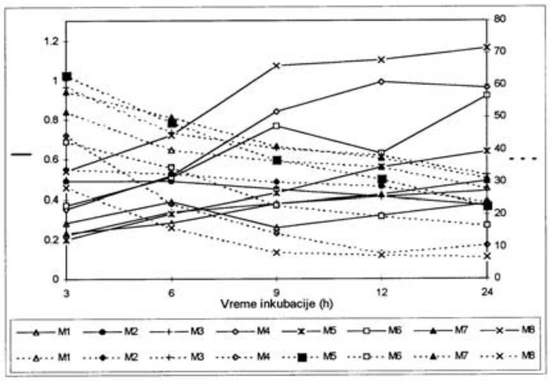
Graph. 2. The effect of the Juniperus communis metabolite to the Agrobacterium tumefaciens population density



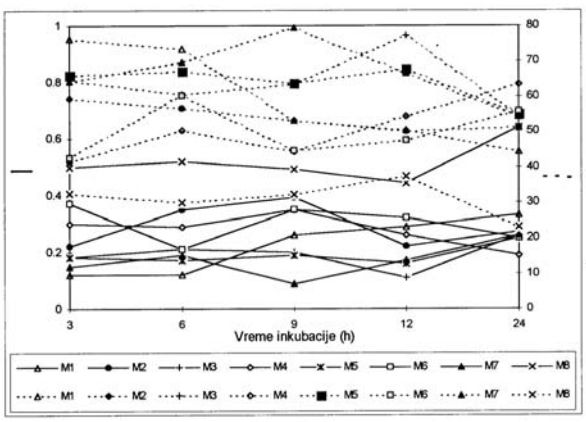
Graph. 3. Efekat metabolita Juniperus communis L. na gustinu populacije Bacillus subtilis



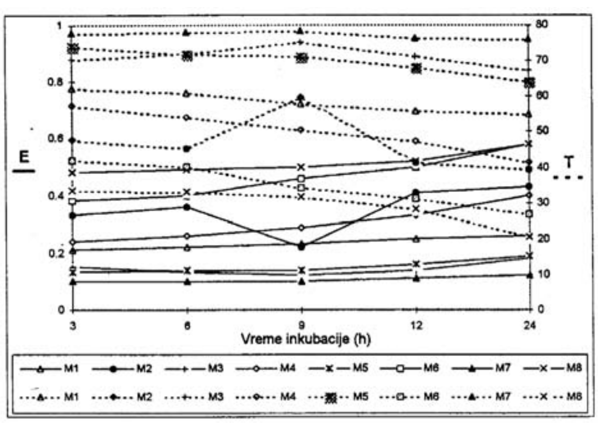
Graph. 4. Efekat metabolita Juniperus communis L. na gustinu populacije Esherichia coli



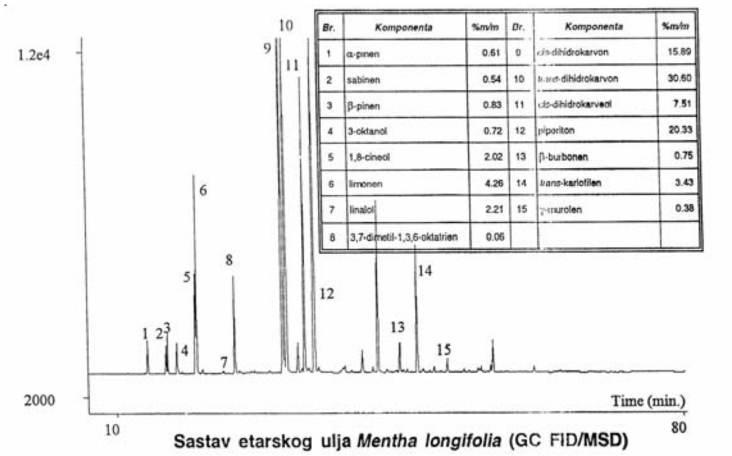
Graph. 5. Efekat metabolita Juniperus communis L. na gustinu populacije Pseudomonas fluorescens



Graph. 6. Efekat metabolita Juniperus communis L. na gustinu populacije Pseudomonas phaseolicola



Graph. 7. Mentha longifolia – Detailed GS-MS analysis of the essential oil



The legend for all graphs: M_1-milled fruits ; M_2- milled remains of the fruits after the alcohol extraction; M_3- alcoholic extract from the fruits; M_4-milled remains of the fruits after the water extraction; M_5-water extract of the fruits; M_6--milled remains of the fruits after the distillation of the essential oils; M_7-essential oil from the fruits; M_8-milled leaves of Juniperus communis

Mentha longifolia is widely distributed in Serbian area and it grows abundantly near streams (where it sometimes forms monocultures), around swamps, in forests, on wetlands and along the roads.

In the essential oil of *Mentha longifolia* was registred 56 components, and 15 of those components was identified and quantified. The main components of this oil are dihydrocarvene (46,49% from which was 15,89% in the cis-form and 30,60% in trans form), piperethine (20,33%), cis-dihydrocarveol (7,51%). The individually concentrations of the residual components was not exceeded 5%. In this sample were also identified α-pinene (0,61%), sabinene (0,54%), β-pinene (0,83%), 3-octanole (0,72%), 1,8- cineole (2,02%), limonene (4,26%), linalool (2,21%), 3,7- dimetyl-1,3,6- octatitriene (0,06%), β- burbonene (0,75%), trans – cariophyllene (3,43%), and γ-murolene (0,38%).

The microbiological research that will continue, showed that essential oil of *Mentha longifolia* has an inhibitory effect to all investigated bacterial strains. The study of the antifungal effect of *Mentha longifolia* essential oil is still in progress.

4. CONCLUSION

The studies of essential oils antimicrobial effect on the area of Serbia showed that metabolites of the plants that have been collected on various habitats has an inhibitory influence to almost all bacterial strains. The fungicidal effect of the Juniperus was not registered, and for this effect of the *Mentha longifolia* essential oil the experiments are still in progress. The intensity of the inhibitory effect depends of the metabolic material extract and it is proportional to the concentration of the metabolite content. The results from tables and graphs points out that investigated essential oils have more bacteriostatyc than bactericidal effect.

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THE INFLUENCE OF NICKEL ON THE *IN VITRO* GROWTH OF SOME POPLAR CLONES FROM THE *LEUCE SECTION*

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Abstract: *This research deals with the effect of nickel presence in growth medium on growth of poplar clones cultivated in tissue culture. Shoots of clones L-12, L-80, L-111/81 and LBM were multiplicated by micropropagation on ACM (Aspen Culture Medium) with 0.5 mg/l 6-benzylamino-purine (BAP) and 0.02 mg/l α-naphthaleneacetic acid (NAA). Terminal shoots, about 1.5cm long, were cultivated 25 days on the ACM medium with addition of 0.1 mM and 0.5 mM of Ni. Parameters investigated in shoot cultures included: length of the main shoot, formation of axillary shoots (shoot multiplication), fresh and dry mass. It was observed that the addition of 0.5 mM Ni (here considered as high concentration) was toxic for shoots of all investigated clones. The symptoms included were decrease of growth vigour and leaf chlorosis. Length, fresh and dry mass, shoot multiplication also decreased compared to control. Low concentration of nickel caused increased length of shoots of clone L-12 and L-111/81. Also, shoots of clone L-111/81 manifested increased fresh and dry mass, but differences were nor statistically significant.*

These results show that lower concentrations of nickel can cause growth stimulation of the clone L-111/81, which indicates its ability for nickel phytoremediation.

Keywords: poplars, nickel, phytoremediation, growth, *in vitro*

1. INTRODUCTION

Nickel is an essential, biogenic element, necessary for plant life. Nickel concentration in dry plant mass is about 0.001μmol/g and hence it is classified as microelement (Epstein (1972)). Nickel is a constituent of urease, the enzyme which is necessary for the hydrolysis of urea obtained by the metabolism of amino acids and nucleotides. Witte *et al.* (2002) found in tomato, cultivated in culture tissue, that urease was not active in the substrate without nickel, whereas the addition of nickel activated this enzyme. Also, the level of urease activity depended on the dose of nickel and it was reduced with the addition of cobalt. In very low concentrations, nickel can have a positive effect on the growth of some species, such as wheat, cotton, tomato, paprika and potato (Mishra and Kar (1974)). Zornoza *et al.* (1999) report that, in the test with sunflower in water culture, the simultaneous supply of plants with NO_3^- and NH_4^+ not only reduces nickel toxicity, but also the growth is stimulated by nickel if the plants are supplied with NO_3^- and NH_4^+.

Nowadays, high quantities of nickel are released to the environment. This is conditioned by the development of industry, activities in mines, smelteries, production of alloys, use of fertilisers, pesticides, as well as by dumping the destructive waste.

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Poplars are plant species which are very often applied in phytoremediation thanks to their characteristics of growth vigour; they tolerate low fertility soils, they have developed root system which can reach the ground water and, which is very important, they can transpire high quantities of water (Aitchison *et al.* (2000)). They can, directly or indirectly, phytoremediate several types of pollutants in several ways, such as: phyto-extraction, phyto-degradation, phyto-volatilisation and rhizo- degrada tion. It is p roved that poplars are successfully applied in the absorption of heavy metals (Lux *et al.* (2000); Kališova-Špirochova *et al.* (2003); Pilipović (2005); Pilipović *et al.* (2005)).

The aim of this study is to determine how nickel affects the growth of shoots of four white poplar clones in tissue culture, depending on the applied concentration of nickel in the growth medium.

2. MATERIAL AND METHOD

White poplar clones L-12, L-80, L-111/81 and LBM (section *Leuce)* were selected for the test because their growth vigour in tissue culture has already been proved (Guzina and Tomović (1989)).

Axillary buds from the trees of different ages in the dormant period were placed in tissue culture. The buds were sterilised in 1.5% chlorine preparation for 10 minutes. After sterilisation, external scales were removed, so that apical meristems covered with a few leaves were introduced to the medium. Aspen Culture Medium was used with the addition of 20 mg/l adenine-sulphate, 100 mg/l myo-inozitole, 0.5 mg/l benzylaminopurine (BAP), 0.02 mg/l α-naphthaleneacetic acid (NAA). The cultures were kept at 26±3 °C in the white fluorescent light with a 16 hour photoperiod. After the development of primary explants, they were transplanted to the first subculture. The material was multiplicated by micropropagation, in which the same growth medium was used as in the introduction to tissue culture. When a satisfactory number of explants were achieved, the shoots about 1.5 cm long were planted on the medium with nickel. Nickel was added to the ACM in the form of nickel sulphate hexahydrate in two concentrations 0.1 and 0.5 mM. The experiment was established as two-factorial, and the factors were the nickel concentration and the poplar clones. The first factor, nickel concentration, had three treatments: control without nickel and two nickel concentrations of 0.1mM and 0.5 mM , while factor clone had four treatments: clones L-12, L-80, L-111/81 and LBM. The experiment consisted of 5 bottles per treatment with 5 explants per bottle. The volume of the bottles was 200 ml, and they contained 30 ml of medium each. After 28 days of growth on the medium with nickel, fresh and dry mass of shoots, length of the main shoot and formation of axillary shoots (shoot multiplication) were measured. Dry mass was measured after the samples were kept for 16 h in the kiln at 60° C. Shoot length and multiplication were determined for each shoot individually, and fresh and dry mass were measured per repetitions, i.e. the shoots from one bottle were measured together. The results were processed by the analysis of variance, and the differences between individual treatments, clones and their interactions were determined and presented by Duncan's multiple range test.

3. RESULTS AND DISCUSSION

Four days after explant introduction, the changes of all clones were observed on the medium with a higher nickel concentration (0.5mM Ni). On the lower leaves of the shoots there were reddish-brown spots. The spots were more marked on the clones L-12 and L-80 compared to the clones L-111/81 and LBM. In this period, there were no visible changes on the shoots which were on the lower concentration of nickel (0.1mM Ni).

After two weeks, it was evident that the higher concentration of nickel was toxic to the shoots of all four clones. The shoots darkened, they were not growing, the lower leaves became red-brown, and the discolouration advanced from the lower leaves towards the upper ones. The lower nickel concentration in the clones L-12 and L-111/81 had a stimulative effect on the growth of shoots, which were longer, lighter green and with fewer axillary buds compared to control. The shoots of the clones L-80 and LBM, which were growing on 0.1 mM nickel, were visibly shorter and had lighter leaves compared to control.

Table 1. Effect of different nickel concentrations on fresh mass (g) of poplar clone shoots

	Concentrations of Ni in mM			
Clone	K	0.1	0.5	Average
L-12	1.903 b	1.177 cd	0.365 e	1.148 a
L-80	2.450 a	1.013 d	0.446 e	1.303 a
L-111/81	1.470 bc	1.615 bc	0.325 e	1.137 a
LBM	1.006 d	0.384 e	0.237 e	0.542 b
Average	1.707 a	1.047 b	0.343 c	
	Clone	Treatment	Interaction	
LSD (0.05)	0.0717	0.3776	0.4294	

After four weeks, the changes were more visible and the differences between the concentrations and the clones more discernible. In the higher concentration, nickel caused the complete cessation of shoot growth. The colour of the lower leaves ranged from dark-brown (L-12 and L-80), through light-brown (L-111/81) to cream (LBM), while the upper leaves of all clones were light-green. Compared to control, the lower concentration of nickel caused the lighter colour of the leaves of all clones, except L-111/81, in which the leaves were reddish along the margin. The shoots of the clones L-12 and L-11/81 were longer, and the leaves of L-12 were smaller, more elongated and narrow, compared to the control.

Table 1 shows that fresh mass per individual treatments of the study clones differs very much, except L-111/81 in which there was no statistically significant difference between the control and the treatment with 0.1mM Ni and clone LBM in which there was no difference between the treatment with 0.1mM Ni and treatment with 0.5 mM Ni. The differences between average fresh mass per treatment, irrespective of the clone were very significant. As for the average fresh mass per clone irrespective of the treatment, the clone LBM showed a significant difference compared to other clones. The greatest fresh mass was measured in the clone L-80 in the control, while the clone LBM had the lowest fresh mass in the treatment with 0.5 mM Ni. It can be noted that the presence of nickel in the medium caused the decrease of shoot fresh mass of all clones in the treatment with 0.5 mM Ni. In the treatment with 0.1 mM Ni, fresh mass of all clones decreased, except clone L-111/81 which achieved greater mass compared to the control in this treatment, but difference was not statistically significant.

Table 2. Effect of different nickel concentrations on dry mass (g) of poplar clone shoots

	Concentrations of Ni in mM			
Clone	K	0.1	0.5	Average
L-12	0.177ab	0.126 bc	0.057 de	0.120 a
L-80	0.220 a	0.114 c	0.051 e	0.128 a
L-111/81	0.152 bc	0.173 ab	0.054 de	0.126 a
LBM	0.104 cd	0.045 e	0.038 e	0.062 b
Average	0.163 a	0.114 b	0.05 c	
	Clone	Treatment	Interaction	
LSD (0.05)	0.0368	0.0430	0.0489	

The Table shows that the dry mass differs per treatments with nickel, except in clone LBM where there was no statistically significant difference in dry mass between the treatment with 0.1 and 0.5 mM Ni. The difference in average dry mass between the clones irrespective of the treatment was significant only in clone LBM, compared to other clones. As for the average dry mass per treatments irrespective of the clone, the differences were very significant. The clone LBM had the lowest dry mass in the treatment with 0.5 mM Ni, while the clone L-80 in control had the highest dry mass. The addition of nickel in the medium caused the decrease of shoot dry mass in all clones, except the clone L-111/81, which achieved higher dry mass in treatment with 0.1 mM Ni compared to control, but difference was not statistically significant.

Table 3. Effect of different nickel concentrations on the length (mm) of poplar clone shoots

	Concentrations Ni in mM			
Clone	K	0.1	0.5	Average
L-12	37.440 cd	60.000 a	22.720 ef	40.053 a
L-80	51.960 ab	37.160 cd	19.823 f	36.314 a
L-111/81	33.760 de	47.480 bc	18.960 f	33.400 a
LBM	26.360 def	26.140 def	18.160 f	23.553 b
Average	37.380 a	42.695 a	19.916 b	
	Clone	Treatment	Interaction	
LSD (0.05)	8.605	10.08	11.46	

It can be seen that shoot length of the clones L-12, L-80 and L-111/81 differs significantly in all treatments, while in the clone LBM the differences between the treatments were not statistically significant. Shoot length per clone, irrespective of the treatment, differed significantly only in the clone LBM, which attained the minimum length. Regarding shoot height per treatment, irrespective of the clone, the minimum shoot length was achieved in the treatment with 0.5mM Ni, which differed significantly compared to other treatmants. Maximal length of shoots was measured in the clone L-12 in the treatment with 0.1 mM Ni, while the clone LBM had the minimal length under the treatment with 0.5 mM Ni. The treatment with 0.5mM Ni had an inhibitory effect on shoot length of all clones, while the treatment with 0.1mM Ni had the stimulative effect on shoot growth of the clones L-111/81 and L-12, and in clones L-80 and LBM it caused inferior lengths.

Table 4. Effect of nickel on the formation of axillary shoots of poplar clones

	Concentrations of Ni in mM			
Clone	K	0.1	0.5	Average
L-12	5.720 a	2.280 c	0.040 d	2.680 a
L-80	4.320 b	0.200 d	0 d	1.507 c
L-111/81	5.200 ab	1.560 c	0.040 d	2.267 bc
LBM	4.360 b	0.520 d	0 d	1.627 c
Average	4.900 a	1.140 b	0.020 c	
	Clone	Treatment	Interaction	
LSD (0.05)	0.7558	0.8849	1.007	

It can be seen that shoot multiplication of the clones L-12 and L-111/81 differed significantly in all treatments, while in the clones L-80 and LBM, the difference between the treatments with 0.1 mM and 0.5 mM Ni was not significant. The highest average value of multiplication, irrespective of the treatment, occurred in the clone L-12, which differed significantly compared to other clones. The differences between average multiplication values per treatments irrespective of the clone were very significant. The maximal multiplication value was measured for the clone

L-12 in control, and the minimal value was achieved by the clones L-80 and LBM in the treatment with 0.5 mM Ni. It can be seen that in both concentrations nickel had an inhibitory effect on the formation of lateral shoots.

The positive effect of the low nickel concentration on the length (clone L-12 and L-111/81) and mass (clone L-111/81) confirms the results reported by Mishre and Kara (1974), according to which nickel had a favourable effect on some plant species, as well as the experiment by Zornoze *et al.* (1999) with sunflower in water culture. The study agrees with the data reported by Kališova-Špirochova *et al.* (2003) in which lead caused the increase of poplar biomass cultivated *in vitro*. The data also agree with the research by Vinterhalter and Vinterhalter (2005), who studied nickel accumulation in the shoots of the plant *Alyssum markgrafii in vitro* and showed that the dry mass decreased gradually with the increase of nickel in the medium. Micropropagation of nickel hyper-accumulator, plant *Hybantus florabundus,* was studied by Bidwell *et al.* (2001) and they found that there was no significant difference in dry mass between control and the shoots treated with nickel. The differences in the data can be explained by the fact that it was the case of two different species.

4. CONCLUSION

In higher concentrations, nickel is toxic to the shoots which is reflected in inferior shoot height, multiplication, fresh and dry mass, compared to control.

The lower concentrations of this metal can also have a stimulative effect on shoot growth of some clones. Nickel caused the increase of shoot length of the clones L-12 and L-111/81 compared to control. Also, clone L-111/81increased fresh and dry mass, but differences were not statistically significant.

Future research should investigate the ability of these clones to accumulate nickel and their possible use in nickel phytoremediation.

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HEAVY METAL CONTENTS IN GROWTH RINGS OF WHITE POPLAR (*POPULUS ALBA* L.) STEM

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Abstract: *This research analyses the lumen of vessels and the contents of heavy metals in white poplar (Populus alba L.) stems at two different sites. The U-shaped DC arc with aerosol supply was applied for the determination of Fe, Mn and Pb in white poplar growth rings. By optimizing the operation conditions of U-shaped arc plasma and by applying the appropriate computer program, the temporal integration of the recorded signals and the detection limits are lowered. The most appropriate signal integration time was (20s), and the obtained limits of detections for Fe, Mn and Pb were 5.8ng/ml, 1.6ng/ml and 2.0 ng/ml, respectively.*

Key words: vessels, *Populus alba*, heavy metals.

1. INTRODUCTION

In the last decades a great number of studies have been published dealing with the effect of air pollutants on plants and man. Especially significant among these studies are the publications on heavy metals, whose presence in plants is toxic in the higher concentrations and causes the decline of the basic cell functions (growth and reproduction).

Plants accumulate trace elements (metals) in the tissues in two ways: a) by absorption from the soil by the root system and b) by absorption from the air by the photo-synthetic organs. For this reason, plants are specific receptors by which heavy metals from the soil, and partially also from the atmosphere, are transmitted to humans and animals (Kadović and Knežević, 2002). In their study on heavy metals in forest ecosystems in Serbia, Kadović and Knežević (2002) report that "the total quantity of metals in the above-ground parts of the plants also depends on the root capacity to absorb metals (Trűby, 1994), transport from the root to the stem (Dambrine et al., 1991) and the transfer of metals from the organs where they were absorbed (Everett, 1992)". Higher concentrations of accumulated metals in the plants occur in the leaf and in the bark of the branches, because they are directly exposed to the pollutants. Veselinović, 2006, reports that air pollutants (SO2, NO3, CO) cause the destruction of chlorophyll in Douglas-fir needles.

The aim of this study was to measure the concentrations of heavy metals (Fe, Pb, Mn) in white poplar (*Populus alba* L.) stems.

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2. MATERIAL AND METHOD

The material for the research originates from two localities: a) the circle of the TENT "A" Obrenovac and b) the nursery of the Institute of Lowland Forestry and Environment in Novi Sad. Stem disks were taken from the felled trees at the height of 1.3 m and they were used for the research of anatomic structure and heavy metal concentration. Microscopic preparations were made for the measurement of growth rings and the widths of the lumen of vessels in the segments of 3 growth rings for each 3 years.

The excitation source was the low current (7.5 A) argon stabilised U-shaped DC arc with aerosol supply. A laboratory modified PGS-2 (Carl Zeiss, Jena) spectrograph with holograph grating (Spectrogon, 2100 grooves/mm) was used as the spectrometer The intensities of the analyte spectral lines were detected by photo-multiplier (Hamammatsu R-3788) and AD conversion card connected to PC. The registered intensities of the signal are accumulated in the integration time of 20s, by applying the corresponding computer programme. The slit is 0.15 mm. Intensities of spectral lines were measured for Fe I (λ= 371.99 nm), Mn I (λ= 403.08 nm) and Pb I (λ= 405.78 nm) at 4 mm distance from the arc axis.

The series of reference solutions (Fe, Mn and Pb) were prepared in the range from 5 ng/ml to 5000 ng/ml, by the dissolution of the concentrated solution (1 mg/ml Merck) with bidistilled water. All the solutions contained 0.5% KCl, known as the spectroscopic buffer. The solutions were nebulised by Meinhard (TR-30-K2) nebulizer connected with the spray chamber.

The samples of growth rings (segments of 3 years) were transferred in the previously washed (15% H_2SO_4) cuvettes made of borosilicate glass (50 ml), and then they were dried at 70°C for 48h and measured. The samples were dissolved in 10 ml of 70% HNO_3 at 80 °C during 24h. The cooled solutions were filtered through Whatmam No. 42 filter paper which was previously treated with 10% HNO_3. After that they were moved to normal containers of 50 ml and filled up with bidistilled water to the marking [1].

3. RESULTS WITH DISCUSSION

After the laboratory research, it was concluded that the heavy metal (Fe, Mn, Pb) concentration in poplar stems was elevated at both localities. The content of heavy metals in the tree originating from Obrenovac was monitored from 1979 in segments of 3 growth rings, and the tree from the locality Novi Sad, from 1985 also in segments of 3 growth rings, Figures 1, 2 and 3. The research shows that the concentrations of Fe, Mn and Pb in the tree from Obrenovac are higher than the concentrations of heavy metals in the tree from Novi Sad. The research of the stem anatomic structure (widths of lumen of vessels) shows that the mean values in the study period are somewhat higher in the trees from the area of Obrenovac. It is known that, by anatomic structure, poplars are diffuse porous species. The vessels have simple resorption plates and their function is to conduct water and mineral substances from the root to the leaf where the process of photosynthesis occurs (Vilotić, 2000).

Table 1. Widths of lumen of vessels (μm)

Area	1979/81 god	1985/87 god	1991/93 god	1997/99 god	2003/05 god
OBRENOVAC	72,2	74,5	79,3	78,7	80,2
NOVI SAD	78,87	71,85	69,47	58,59	70,4

Figure 1. Concentration of Fe in white poplar (Populus alba L.): O- Obrenovac; NS- Novi Sad

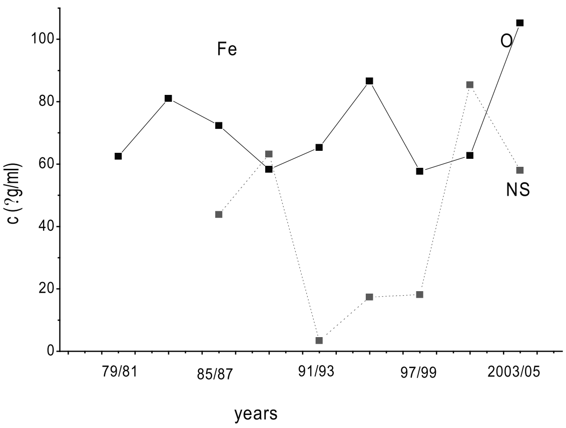

Figure 2. Concentration of Mn in white poplar (Populus alba L.): O- Obrenovac; NS- Novi Sad

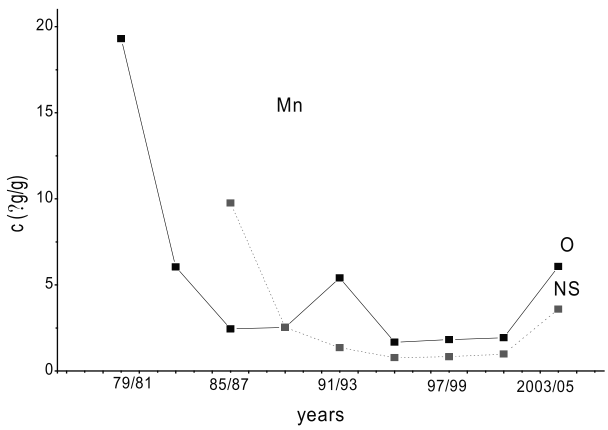

Figure 3. Concentration of Pb in white poplar (Populus alba L.): O- Obrenovac; NS- Novi Sad

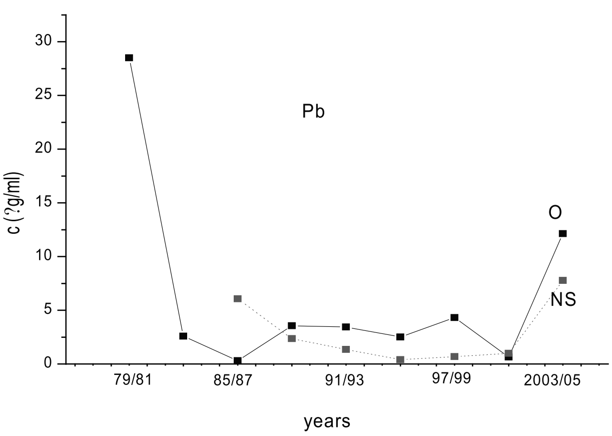

Table 2. Measured concentrations of Fe in μg/ml

1979-1981	62.53	1985-1987	43.81
1982-1984	81.05	1988-1990	63.2
1985-1987	72.34	1991-1993	3.38
1988-1990	58.34	1994-1996	17.4
1991-1993	65.35	1997-1999	18.13
1994-1996	86.63	2000-2002	85.44
1997-1999	57.65	2003-2005	58
2000-2002	62.74		
2003-2005	105.22		
Obrenovac		Novi Sad	

Table 3. Measured concentrations of Mn in μg/ml

1979-1981	19.3	1985-1987	9.76
1982-1984	6.04	1988-1990	2.53
1985-1987	2.45	1991-1993	1.35
1988-1990	2.53	1994-1996	0.77
1991-1993	5.41	1997-1999	0.82
1994-1996	1.67	2000-2002	0.98
1997-1999	1.82	2003-2005	3.59
2000-2002	1.93		
2003-2005	6.07		
Obrenovac		Novi Sad	

Table 4. Measured concentrations of Pb in μg/ml

1979-1981	28.51	1985-1987	6.07
1982-1984	2.59	1988-1990	2.35
1985-1987	0.31	1991-1993	1.35
1988-1990	3.56	1994-1996	0.39
1991-1993	3.44	1997-1999	0.69
1994-1996	2.51	2000-2002	0.98
1997-1999	4.31	2003-2005	7.77
2000-2002	0.64		
2003-2005	12.14		
Obrenovac		Novi Sad	

4. CONCLUSION

The research shows that the concentrations of Fe, Mn and Pb were elevated in the tree at the locality TENT "A" Obrenovac. It was concluded that from 2003 to 2005 there was a sharp increase of Pb and Mn at both localities, as well as Fe at the locality Obrenovac, while Fe concentration in Novi Sad was reduced. The above indicators point to the need of further research, to find out the causes and influence the relevant institutions in the aim of environmental protection.

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INTEGRATED APPROACH TO THE PROTECTION OF FOREST ECOSYSTEMS AS PART OF SUSTAINABLE DEVELOPMENT STRATEGY IN SERBIA

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Abstract: *For successful environmental and forest ecosystems management, it is necessary to comprehend, accurately access and use a large number of information on environmental management and protection. Sustainable development represents a frame for the formulation of policy and economic and social improvement strategy, which must not endanger the future generation by destroying the non-renewable resources and by long-term devastation and pollution of the environment. Sustainable development strategy is based on well-balanced economic, social and environmental protection goals at the national and local levels. As a part of this strategy, forest ecosystem cannot be independent, it is an integral part of the environment and its integrated protection implicates the elaboration of a complete and long-term programme of activities. This paper presents the key elements, goals and principles of national sustainable development strategy and the ways of its realisation as well as the measures which should be carried out to achieve the integrated protection and improvement of forest ecosystems (legal, technical-technological, organizational, planning, etc.).*

Key words: sustainable development, forest ecosystems, integrated protection, national sustainable development strategy

1. INTRODUCTION

The concept of sustainable development has been designated as the key of the European Union development policy, and the integrated approach – as the base of the environmental protection policy and all policies at the local, regional and global levels. It is especially significant to harmonise and integrate the development policy and environmental protection policy in the situations and regions with the accelerated environment degradation, accelerated pollution and depletion of natural resources due to the implementation of inadequate technologies and absence of adequate norms, ecological principles and standards.

Integrated environmental protection includes the development and the complex implementation of multidisciplinary and interdisciplinary measures, methods and procedures and their incorporation in the sectoral development policies aiming at the sustainable development, protection and improving the quality of the environment and biosphere in general. Biodiversity management requires a higher level of cooperation and coordination, compared to traditional, sectoral methods of utilisation of natural resources, because populations, species, ecosystems, ecological processes and biogeochemical cycles which support the life in the biosphere, are not subjects of the state or administertive boundaries, sectoral restrictions, local, national or international agencies and corporations, community areas or private estates. The solving of global problems of ecological crisis, which are reflected in the depletion of ozon layer, climate disturbances,

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biodiversity risks, loss of arable soil, forest destruction, acid rains and other adverse processes which degrade and contaminate the environment, requires the engagement of all actors at the local, regional and global levels.

In contrast to many other ecological systems, forest ecosystems are not only the source of significant natural raw materials, but also the regulators of important natural processes, which can enhance the environment. Forests are efficient reducers of harmful anthropogenic impacts and can help remove the disturbances occurring in nature, but only in cases when unfavourable impacts have not exceeded certain thresholds. Starting from the above problem, the utilisation of natural resources should be considered as the system of measures and reasonable limitations, directed to nature conservation, not only in the state as it was before human impacts, but to the conservation and transformation within the limits and extents that will ensure permanently favourable environmental conditions for humans and all other living beings, and not only for present, but also for future generations.

Integrated approach to the protection of forest ecosystems and their valorisation from the economic, social and ecological aspects, represents the base for the identification of the measures to be implemented in the aim of improving the state of forest ecosystems in Serbia and their sustainable utilisation.

2. GOALS, ELEMENTS AND PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Sustainable development is a new approach to the quality of human life. The goal is to establish the balance between the needs and opportunities, desire to possess material goods and the need for healthy and pleasant environment, as well as the need that the society reaches the higher civilisation level.

According to M. Lješević (2001), the basic components of sustainable development are:

- economic and technological efficancy;
- efficient implementation of social policy ;
- meeting the educational, health, cultural and other human needs and rights;
- efficient demographic policy, which means the balanced demographic development and adequate spatial distribution of the population;
- rational exploitation of natural resources;
- environmental protection and improvement;
- protection of natural and cultural-historical goods and values.

There is a continuous interdependence among the above elements and none of the segments should be observed separately.

The basic principles of sustainable development and the only proper way for its establishment in Serbia are: comprehensive approach (interdisciplinary and multidisciplinary), coordination in the formulation and adoption of sectoral development policies and in the implementation of individual measures and methods, implementation of scientific and technological results and innovations, cooperation and exchange of experiences with the countries and institutions which have achieved enviable results in this field, information and the participation of the local community.

As for the new concepts, strategies and experiences originating from the European developed countries, whose economic situation, degree of technical development and ecological awareness differ greatly from the existing situation in our country, they should not be accepted without reserves, because each country is different so it must find its own way how to achieve sustainability. The positive experiences should be accepted, but they should be modified before their implementation, depending on the conditions which prevail in Serbia. The approach to the strategy of sustainable development should be defined based on the economic conditions, legal regulations, available resources, degree of protection of individual areas and numerous other factors.

3. NATIONAL STRATEGY OF SUSTAINABLE DEVELOPMENT

The strategy of sustainable development is defined as a coordinating and continuous process of balancing the economic, social and environmental protection goals at the national and local levels. The basic elements of the effective National strategy of sustainable development are:

- State ownership and sntrong political decision;
- integration of economic, social and environmental protection goals;
- wide participation and efficient partnership;
- capacity building and the development of appropriate conditions;
- results and methods of implementation (Radosavljević Z., Ristić, S., 2005).

The experiences in the strategy elaboration and implementation are different. Regarding the measures of forest ecosystem protection and enhancement in Serbia, in the aim of sustainable development in Serbia, special attention should be focused to the execution of:

- normative-legal;
- technical-technological;
- planning;
- organisational, and other measures.

Normative-legal measures ensure that forest improvement and forest protection should be regulated by the appropriate legal regulations. In the formulation of the Forest Law, and the Laws on water, land use, hunting, environmental protection, etc., as well as in the design of spatial plans, their harmonisation should be insisted on. At the same time, all the international commitments resulting from the adopted declarations and conventions should be taken into account (Declaration on human environment UN - Stockholm 1972, UN Declaration on Environment and Development - Rio Declaration 1992, Convention on Biodiversity Conservation 1992, Kyoto Protocol 1997, Lisbon Resolution, 1998, etc.).

Technical-technological measures – include general and special goals of forest management, as well as the measures for their realisation. General goals of forest management relate to all forests in the forest area. They are:

- sustainable production and permanent increase of the yield,
- maximum production of wood volume,
- conservation and increase of forest value,
- economicity and profitability,
- development and strengthening of multiple use forest functions.

Pursuant to the valid Forest Law, forests as the goods of general interest, have the benefit of special protection and they should be managed so as to conserve and improve their state with the simultaneous rational utilisation, to meet the demands of the society. The realisation of general goals of forest management greatly depends on the present state and on the consistent implementation of silvicultural, technical and management measures regulated by the special forest management plan.

Based on the well-known criteria for the evaluation of the ecological value and characteristics of the land, as well as starting from the actual forest state, special goals should be identified as the management tasks of long-term character. Special goals of forest management are:

1. biological – silvicultural goals, which ensure sustainable and permanent increase of forest increment and yield, i.e. the maximum production of wood volume of the best quality and value, and the utilisation of all site conditions;
2. technical goals, which provide the conditions for the realisation of the biological-silvicultural aims of forest management (road construction, forest equipment, etc.);
3. production goals, which identify the potentials of the forest production as per assortments and the quantity needed to satisfy the demands of wood processing industry and other consumers.

Planning measures include the new approach to forest management planning. All the methods and models of planning in forestry should be ecologically based, and their goal should be the utilisation of all forest function. Planning in forestry must not and should not be outside the planning of overall social needs.. Taking into account the interrelationship of forestry and agriculture, town planning, industry, traffic, tourism and other activities, planning should be complex and integrated.

Organisational measures include the finding of such an organisation model which will be exclusively in the interest of the promotion and optimal utilisation of all potentials and resources in forest areas. Special problems in the organisation of management are property relations. Namely, in addition to state and public forests, great forest complexes are in private ownership, or owned by cooperatives, Monasteries, agricultural enterprises, water management, Municipalities, etc. The optimal utilisation of forest potentials requires an integrated organisation, planning and management of all forests in the area, irrespective of the ownership.

The adequate protection of forest ecosystems can be achieved if plan and normative measures are accompanied by the adequate technical-technological, organisational, regulation and operation measures at the international, national, regional and local levels.

4. CONCLUSION

Integrated environmental protection includes the development of the comprehensive and long-term programme of activities. It signifies the beginning of the new social attitude to the environment, the land and natural resources, with the full awareness of the responsibility to the future generations. The development today must enable the development tomorrow, it should be sustainable. For this reason, the imperative of the future existence of the civilisation is the reasonable attitude to the utilisation of available resources of the atmosphere, hydrosphere, lithosphere and biosphere.

The strategy of sustainable development in Serbia should be the framework for the strategies at the lower levels of management, as well as for sectoral plans and programmes. In this sense, it is necessary to develop the strategy of sustainable development in the forestry sector.

To ensure the multiple forest functions and to bring the forests to the most favourable (functional) state and also to keep the optimal state permanently, it is necessary to:

- improve the state of the existing forests;
- improve the seed and nursery production;
- afforest the bare lands;
- identify the causes of forest dying and undertake more intensive measures of protection;
- increase the volume of other resources of forests and forest ecosystems.

Integrated approach to the protection of forest ecosystems requires the correspondence, the interaction and harmonised implementation of different instruments of protection, starting from the legislation and legal, via organisation-institutional and economic to informatics and ecological. In the aim of improving the state of forest ecosystems in Serbia, their protection and sustainable utilisation, it is necessary to:

- by legal acts, establish the balance between environmental protection and economic and social development on the one hand, and utilisation of natural resources, on the other hand;
- continue, but also intensify the existing co-operation between individual institutions in Serbia (Ministry of Agriculture, Water Management and Forestry of the Republic of Serbia, Ministry of Science and Environmental Protection, SE "Srbijašume", SE "Vojvodinašume", Faculty of Forestry – Belgrade, Institute of Forestry – Belgrade, Institute for Lowland Forestry and Environment – Novi Sad, The Institute for nature protection of Serbia, etc.) in the aim of conceiving and implementing the good-quality forest policy in Serbia;
- disable and prevent the actions that condition the forest weakening and damage;
- timely detect the significant changes in the function of forest ecosystems, define their characteristics and analyse the consequences which can result;
- monitor and control the environment and prevent the unfavourable effects;
- establish new relations and evaluations, which will incorporate the value of natural resources and the costs of environment conservation, protection and improvement in the product price;
- establish more intensive and better-quality co-operation with the European countries in the field of protection of forest ecosystems, by the exchange of information and experiences and by the participation in international projects dealing with this subject;
- publish and present to the public the actual state and the necessary financials for the achievement of a longer-term protection of forest ecosystems;
- include the local population in the formulation and realisation of forest policy;
- implement the appropriate criteria and indicators which will be considered in forest management planning, in order to correct the standards of utilisation of forest ecosystems, reduce the detrimental ecological effects, ensure the survival of forests for future generations, enable the economic, social and ecological contribution of forestry as the component of sustainable development of the entire society.

The very idea on sustainable development, as human and promising, can become only an illusion if it is not subjected to professional critical analysis and if it is not reflected in the state documents and legislation, i.e. if a whole series of governance and other activities on its implementation is not regulated.

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BIOMASS PRODUCTION OF WILLOW CLONES IN THE PRESENCE OF CADMIUM

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Apstract: *The aim of this study was to determine bioproduction potential of four willow clones growing in the presence of Cd. Willows were grown in a semi-controled environmental conditionst (greenhouse), in nutrient solutions by water culture. Woddy cuttings were rooted in deionised water and after one month treated with two cadmium concentrations (10^{-4} M, 10^{-5} M and 0 M) in a standard Hoagland solution. Basic morfological parameters were measured on fresh plant material: shoot mass, height and diameter near the shoot base, leaf area and leaf mass, root mass and volume. Increasing Cd concentrations in plant tissue caused decreased values of almost all growth parameters. It was more evident at higher Cd level applied. Morphological responses were specific for each researched clone. Clone 0408 (Salix nigra) showed the highest tolerance to treatment At lower Cd concentration (10^{-5} M) some growth parameters were not affected. In clones 68/53/1, (Salix alba), SM 4041 (Salix matsudana) and 0408 (Salix nigra), Cd caused increase in root mass and volume.*

Key words: *Salix*, bioproduction, cadmium, phytoremediation

1. INTRODUCTION

Cadmium as a toxic element is an increased threat to human health as well as to productivity of plants and animals. The use of willow clones for decontamination of environment polluted with Cd (phytoremediation), costs considerably less than some conventional treatments. Unlike some conventional methods, this solution is permanent, there is no risk to secondary pollution and the soil is left fertile (Robinson et al., 2000). Number of literature references suggested that willows have excelent potential for Cd phytoremediation because of their high biomass production and high bioaccumulation degree (Landberg & Greger, 1994; Greger et al., 1995; Greger & Landberg, 1999; Robinson et al, 2000; Klang-Westin & Eriksson, 2003).

The aim of this study was to determine bioproduction of four willow clones, grown in nutrient solutions containing Cd, and therefore, to distinguish genotypes with the highest tolerance to cadmium.

2.MATERIALS AND METHODS

The experimental material consisted of four willow clones: 1. *Salix alba* – clone 68/53/1; 2. *Salix alba* – clone 106/54/0; 3. *Salix matsudana* – clone SM 4041; and 4. *Salix nigra* – clone 0408. Willows were grown in a semi-controled environment (greenhouse), in nutrient solutions by method of water culture. Solutions were permanently aerated and covered to prevent algae development. Cuttings of clones (approximately 0,2 m long) were placed in a deionised water and after one month, rooted willow cuttings were treated with two cadmium concentrations (10^{-4} M and 10^{-5} M) in a standard Hoagland solution. Control plants (0 M Cd) were grown without Cd in

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nutrient solution. Solutions were replaced every two weeks and pH was between 5 and 5,5. Plants were harvested after 70 days. Basic morfological parameters measured on fresh plant material were: shoot mass, height and diameter near the shoot base, leaf area and leaf mass, root mass and root volume. Statistical analyses was conducted using Duncan's Multiple Range Test, at the level of significance p=0,05. Mean values in the tables followed with the same letter, did not differ significantly. Values decreased following the alphabetical order.

3. RESULTS

Plants grown on Cd 10^{-4} M treatment showed chlorosis. Chlorosis of the leaves became visible after 12 days of cadmium treatment. At the moment of harvesting, almost all plants had few visible chlorotic younger leaves, at the top of the shoot.

According to our results, control plants of all clones had the highest shoots, compared to plants treated with Cd (Table 1). There were significant differences between clones, particularly in their responses to Cd treatment. Clones 1 and 2 showed very strong inhibition of growth, especially on higher concentration of Cd. Clone 3 and especially clone 4, however, demonstrated tollerance to Cd treatment.

Table 1. Shoot height of clones depending on Cd treatment (cm)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	47.90 a	28.30 g	36.68 ef	37.63
2	46.02 abc	18.55 h	32.65 fg	32.41
3	41.83 cd	35.43 ef	39.23 de	38.83
4	47.45 ab	39.30 de	43.08 bcd	43.28
average	45.80	30.40	37.91	

For these two clones, there is no significant difference between the height of control plants and plants treated with 10^{-5} M Cd.

Shoot diameter showed significant differences beetween treated and not treated plants (Table 2). Clones 3 and 4, again display significantly better tolerance, compared to clones 1 and 2.

Table 2. Shoot diameter of clones depending on Cd treatment (mm)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	2.87 a	2.03 f	2.20 def	2.37
2	2.53 bc	1.57 g	2.12 ef	2.07
3	2.37 cd	2.13 ef	2.12 ef	2.21
4	2.57 b	2.35 d	2.23 de	2.38
average	2.58	2.02	2.17	

Decrease in shoot mass was evident in all clones (Table 3), particularly on the cadmium concentration of 10^{-4} M. However, clone 4 distinguished with decrease in mass for only one level of significance.

Table 3. Shoot mass of clones depending on Cd treatment (g)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	2.08 a	0.72 d	0.91 d	1.24
2	1.66 b	0.31 e	0.84 d	0.94
3	1.47 b	0.92 d	1.05 cd	1.15
4	2.07 a	1.35 bc	1.46 b	1.62
average	1.82	0.82	1.06	

Leaf area decreased significantly according to Cd treatment applied (Table 4). Clones 1, 3 and 4 had not show significant differences between cadmium concentrations of 10^{-4} M and 10^{-5} M. Clone 3 showed no change in leaf area to cadmium treatment, since there was no difference between control and treated plants. This clone, however had the smaller leaf area in general, when compared to all other clones. Clone 4 can be distinguished with the largest leaf area in general.

Table 4. Leaf area of clones depending on Cd treatment (cm2)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	10.90 b	4.51 fg	5.25 efg	6.89
2	10.53 b	4.25 g	6.67 d	7.15
3	6.45 de	5.75 def	5.39 defg	5.86
4	13.19 a	9.19 c	8.46 c	10.28
average	10.27	5.93	6.44	

Parameters leaf area and leaf mass varyed very similarly according to investigated clones and Cd treatment (Table 5). Clone 4 showed significantly highest leaf mass. Treated plants of clone 4 showed decrease in leaf mass compared with control plants, but there were no significant difference between Cd treatments.

Table 5. Leaf mass of clones depending on Cd treatment (mg)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	151.17 b	69.50 f	86.00 de	102.22
2	124.83 c	56.00 g	93.83 d	91.56
3	84.67 de	75.83 ef	76.50 ef	79.00
4	180.00 a	134.17 c	129.50 c	147.89
average	135.17	83.88	96.46	

Treatment respones in root mass and root volume (tables 6 and 7) for each clone was specific. Except for clone 2, which showed inhibition of root growth in the presence of Cd, all other clones showed increase in root mass and volume.

Table 6. Root mass of clones depending on Cd treatment (g)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	0.998 c	1.285 ab	0.938 c	1.074
2	0.773 de	0.482 g	0.678 ef	0.644
3	0.762 de	0.795 de	1.18 b	0.912
4	0.59 fg	1.393 a	0.89 cd	0.958
average	0.781	0.989	0.922	

Table 7. Root volume, LSD – 0,1482 (ml)

clone/treatment	control	Cd 10-4	Cd 10-5	average
1	1,00 bc	1.37 a	0.97 c	1.11
2	0.80 de	0.48 f	0.71 e	0.67
3	0.75 de	0.75 de	1.13 b	0.88
4	0.70 e	1.38 a	0.90 cd	0.99
average	0.81	0.99	0.93	

Clone 3 had significantly stronger root growth on smaller Cd concentration (10^{-5} M), but there was no significant difference between control groups and the ones treated with Cd concentrations of 10^{-4} M. For clone 1 and 4, significant increase in root mass and volume is evident for both Cd concentrations, but this increase was more obvious for plants treated with Cd 10^{-4}M concentration.

4. DISCUSSION

The specific difference of almost all investigated growth parameters between clones, was evident. These differences were particularly expressed in specific clones reaction to Cd treatment. Obtained genotypic specificity in morphological response to Cd environmental presence is in agreement with previous researches (Greger & Landberg, 1999; Robinson et al, 2000; Vassilev et al., 2002; Klang-Westin & Eriksson, 2003; Hakmaoui et al., 2006). Clone 4 can be ditinguished as the best one according to its tollerance to toxic influence of cadmium. This clone had the the highest bioproduction in general. Clones grown on the 10^{-5} Cd concentration showed very low inhibition in growth. Concentration 10^{-4} M in nutrient solution caused strong stress effect, which means that significant decrease in almost all growth parameters were recorded. Therefore, environmental cadmium contamination level of 10^{-5} M can be used as a critical Cd load close to limits of plant unaffected growth. This is the first step in understanding the potential of Cd phytoextraction in polluted environment, regarding obtained results. It is well known that phytoremediation ability depends on the genotypic ability of cadmium uptake and accumulation (Chaney, 1983). Uptake of heavy metals by plants is usually the result of "bioavilability" of the metal in the growth medium, the transpiration rate of the plant, and the selective uptake of that metal by the plant (Chardonnens et al., 1998). *Salix* species have high potential for removing Cd from contaminated environment. Defined as high accumulators and not hyper accumulators of Cd (Klang-Westin & Eriksson, 2003), strategy of using willows in phytoremediation process is large production of biomass in polluted environment.

It is evident that cadmium specificaly stimulated root growth for clones 1, 3 and 4. Acorrding to Greger & Landberg (1999) Cd transport to the shoots in different *Salix* clones represents 1 to 72 % of the total metal uptake, which could explain different root growth responces to cadmium treatment. The complex mechanisms of Cd uptake and translocation is studied by a number of authors (Whiting et al., 2000; Vassilev et al., 2002; Nylund, 2003; Lux et al., 2004), however the cause for this increase of rooth mass and volume, influenced by Cd, needs further analyses as an interesting topic for future researches.

5. CONCLUSION

Genetic variability of researched clones was evident in their bioproduction responses to cadmium treatment. Clone 4 can be distinguished according to its highest tolerance to Cd treatment. All clones generally, showed significantly weak growth inhibition on Cd concentration of 10^{-5} M, or even no growth inhibiton compared to control plants. Therefore, environmental cadmium contamination level of 10^{-5} M can be used as a critical Cd load close to limits of plant unaffected growth. Cadmium root growth stimulation is established in some clones.

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MULTIFUNCTIONAL POTENTIALS OF MAKIŠ AS A PICNICKING AND RECREATION COMPLEX

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Abstract: *Belgrade, a two-million capital – metropolis which pretends to be the centre of all-inclusive tourist offer, lacks the complexes of diverse picnicking-recreation contents in the natural environment of forest and aquatic ecosystems, which could satisfy the demands not only of Belgrade citizens, but also of foreign visitors, as an attractive ambiance for a longer stay.*

Such a potentially very valuable tourist-picnicking and recreation potential, but for the time being unmanaged, is the complex Makiš, which with Ada Ciganlija and the Sava banks makes a unique space of about 1,000 hectares, within which about 500 hectares are under forests in state ownership.

Today, only Ada Ciganlija with its lake and the terrestrial part is partly landscaped as a picnicking-recreation complex with different contents, but it is insufficient for two-million Belgrade and it has no further possibility of spatial and other spreading within the present boundaries. However, if Makiš, which is adjacent to Ada Ciganlija and the river Sava, was developed in the sense of picnicking-recreation with diverse sport terrains and features for amusement and relaxation, the conditions would be created for the visits and recreation of more than a million visitors daily, and each visitor could have the feeling of free sojourn in natural, healthy environment where they have available all-inclusive recreation and sport activities.

Man has been linked to a forest since his origin. The sites of the first communities were forest ecosystems and there they satisfied all their existential needs.

Key words: Makiš, forest ecosystems, recreation, sport-recreation terrains.

1. THE ATTITUDE OF MAN AND HUMAN COMMUNITY TO GREEN SPACES

The attitude to forests, as the spontaneous natural formation, has been changing throughout the civilisation development.

In the absence of natural forest ecosystems in his direct surroundings, men created the anthropogenic permanently green spaces, because since the ancient times gardens have always been considered the synonym of heaven, the place not only of material, but also of spiritual well-being and emotional enjoyment in the natural beauties.

From the times immemorial man has admired plants, and especially the trees, aware of their beauty, sustainability and renewability.

Trees are the subjects of many different myths and legends. In Greek mythology each tree was related to a god: for example, oak belongs to Zeus, pomegranate belongs to Hera, olive belongs to Athens, etc.

In Egypt, in 2400 B.C., magnificent gardens were established, which were the privilege of the pharaohs and the elite of that time.

In ancient Greece, the gardens were created under the influence of Persian and Egyptian gardens. For the first time, parks were established as urban public areas which were the meeting places of the philosophers and the educated elite. Hippocrates in the 4th century B.C. observed the negative effect of urban life on human health and the soothing effect of the vegetation. He studied and described more than 250 species of plants.

The old China is the birthplace of the landscape style of green spaces which supports nature. Each part of the garden: plants – water – stone, are placed in a definite position, and united they form the base of the Chinese style named phenshon.

The hanging gardens of Babylon are famous and they belong to the Seven Wonders of the World in the ancient times.

In Europe, during 16th and 17th centuries many gardens were established, predominantly under the influence of the Renaissance and Baroque. The greatest significance for the landscape architecture of the 18th and 19th centuries is that of the English Landscape Park which originated under the influence of the Chinese and Japanese landscape art.

It is generally thought that the most valuable attributes of a large city or a metropolis are park areas, as the expression of the democracy of urban governance which devotes the most valuable parts of the expensive urban land to the parks as public goods which are used by all citizens as a healthy environment. There are numerous examples: in the centre of Rome, there is Villa Borghese with a park on more than 20 hectares. The Luxemburg Park in Paris and the Boulogne Forest with 846 ha are even larger. The Vienna Stadt Park is one of the large parks in the centre of the city. In New York, it is said for Central Park on the area of 342 ha in the centre of Manhattan, that it is the greatest New York architectural creation and it was established in 1840. The designer F.W. Olmsted had the task to create a democratic space, i.e. a part of geography in which all social classes, by their mutual desire of liberation from the tension of the artificial urban environment, have the green spaces on their disposal. This park has remained even today the New York pride, the meeting place of New York citizens and the foreigners, the famous stars and the unknown people, the rich and those who are not – in one word, all the population of New York and the strangers in the city.

Let us mention the famous Hyde Park in London, on about 250 hectares, which shows that numerous metropolises succeeded in keeping their most conspicuous green spaces throughout all historical events.

Belgrade has many small parks or green spaces in the core urban tissue, but with very modest potentials of all-inclusive recreation and other demands of the citizens, and even these spaces are endangered by intensive urbanisation.

The elite tourist attractive parks are few. It is primarily the Kalemegdan Park with the fortress, which has a great historical and cultural value and a very favourable location above the confluence of our two large rivers, which make it attractive for both domestic and foreign visitors. The other, historically significant park is Topčiderski Park with Milošev Konak, with modest amusement and recreation potentials. The green spaces between the confluence of the Sava and the Danube on the New Belgrade side are anaemic, without attractive contents, except for the Museum of Modern Art, which attracts the lovers of fine arts.

In the past twenty years, a picnicking-recreation natural environment near the city core, which attracts massive visits of Belgrade citizens, is Ada Ciganlija, with the lake, on which in summer months there are more than 300,000 visitors from the city. However, this island (now peninsula), despite the numerous playgrounds for various sports, walking paths and bicycle paths, landscaped lake with relatively clean bathing water, enriched with sport and recreation contents on water, gravel beaches around the lake, has not been completely landscaped. To make the entire area of Ada available to the citizens of Belgrade, it is necessary to remove the illegal residential settlements in the downstream part of Ada, and manage that part with the already existing small lake for the picnickers; it is necessary to free the right bank of the river Sava which is now occupied by private houses on water, and which form a continuous "Street" on water and they make it impossible to the visitors of Ada Ciganlija to visit the bank of the main stream of the river Sava; it is necessary to conserve the naturalness of the forest ambiance of the stands in the upper end of Ada Ciganlija, which are managed by PE "Srbijašume"; the internal structure and the stand canopy should not be disturbed too much by tending measures; the narrow paths through these stands could enable the visitors to experience the sense of beauty by walking through the forest part in the undisturbed ambiance of the natural forest.

However, Ada Ciganlija, despite its attractiveness, is not a sufficiently large picnicking and recreation space for two-million Belgrade – the future metropolis.

Fortunately, the complex of Ada Ciganlija and the right bank of the river Sava have the continuation in the relatively unpopulated space Makiš, which contains about 500 hectares of state-owned forest ecosystems managed by the Public Enterprise "Srbijašume", and the unidentified area of agricultural land and other land uses which should be purchased by the City. The boundaries of Makiš are:

Radnička Street – road to Železnik – railway station Makiš – road Železnik - Makiš – the Sava bank.

Within the above boundaries, there is a water factory, because of which the underground springs should be protected against contamination – the reserves for the water factory supply.

By uniting Ada Ciganlija and Makiš, a unique picnicking and recreation space of park and forest-park type would be obtained, with the area of about 1,000 hectares. It should be designed so that it contains numerous subjects for sport and recreation and amusement function of the high rank for the complete satisfaction of both the visitors of the high economic standard and the visitors of the modest economic-social groups, so that they do not disturb each other.

By its modern spatial-regulation and purposeful design of the functional management, with the contents and values, Belgrade would get its "Boulogne Forest" – the Belgrade Forest which could become the "pearl" of the metropolis, attractive to international tourists, the most valuable and the most attractive part of the city – the tourist brand of Belgrade.

In the preliminary development research, the entire recreation complex of about 1,000 hectares was analysed through three minor entities, functionally inter-related. They are: the existing space of Ada Ciganlija, then the space intended for creating a special spatial unit – "Children amusement and recreation park" (small "Disneyland"). According to a preliminary idea it will be designed to become a high-rank urban-landscape aesthetical feature, with numerous diverse amusement-recreation structures in the space surrounded with the rich ornamental plant species, gurgling cascading streams and small lakes, magnificent light effects, sculptures in the open space and other numerous contents of both stationary and dynamic objects which will excite the child's imagination. This complex is directly linked to the large complex of more than 500 hectares of parks and park forests with multiple sport and recreation contents in the natural ambiance of the landscaped forest ecosystems with diverse trees and shrubs.

The State-owned forest ecosystems managed by the Public Enterprise "Srbijašume", Forest Estate "Beograd", are predominantly high forests of anthropogenic origin. They are floristically diverse, because they consist of several plant communities mosaically distributed in space on about 380 hectares.

In addition to state forests, the future picnicking-recreation complex Makiš also includes about 400 hectares of private holdings, predominantly of agricultural land on which the owners grow agricultural crops with the intensive application of mineral fertilisers and pesticides, thus contaminating the ground water and the springs of the water factory for the city of Belgrade. By purchasing the private holdings within the boundaries of the picnicking-recreation complex, the property rights will be solved and in this way the undisturbed realisation of the designed contents will be made possible.

2. RESEARCH OF THE PRESENT STATUS AS THE BASE FOR THE DRAWING UP OF THE PRELIMINARY AND MASTER PROJECTS

A significant part of Makiš area, particularly within and along the boundaries of the existing forest ecosystems, is contaminated by numerous illegal dumpsites for different waste, houses and other buildings with toilets, cesspools and detrimental contents which endanger the environment. They are the disgrace of the city, so it is necessary to perform a preliminary research, analyses and mapping as the base for the drawing up of the preliminary and master projects of the future status. It is necessary to perform the following preliminary research:

- Research, definition and mapping of the optimal external limit of the future picnicking-recreation complex. The approximate external boundary would extend along Radnička Street - road to Železnik, on the south side not far from the railway station, on the west side along the road Železnik – Makiš – the Sava bank, and on the north side along the river Sava to the downstream end of Ada Ciganlija, which would in future be a unique picnicking recreation complex with Makiš;
- analysis and mapping of the land areas per cadastral communities, cadastral parcels, land use and ownership;
- analysis, identification and mapping of the location of the existing dwelling houses depending on the building quality, number of flats per houses, according to the categories, and the arguments for the need for dislocation;
- cadastre with the cartographic survey of toilets, septic holes and illegal dumpsites for refuse;
- cadastre with mapping of the number and length of waterworks;
- cadastre of the sewerage network with the location of the waste outgoes and foul water;
- cadastre of the existing economic buildings, separately for production and services, with the analysis of the effects on the environment;
- analysis of the status, with the cadastre and mapping of the existing internal road network, depending on the quality: asphalt, macadam, soft roads and paths;
- cadastre of channels with mapping, with the analysis of the present hydrologic functions;
- mapping of natural watercourses with the analysis of the degree of water pollution;
- vegetation research and mapping of forest ecosystems with the analysis of forest stand conservation and silvicultural origin.

The above research with the analysis of the existing condition could be performed by the Institute of Forestry in Belgrade, in cooperation with the Faculty of Forestry, because they have the scientific and professional potentials.

3. THE PRELIMINARY CONCEPT OF MANAGEMENT OF THE PICNICKING-RECREATION COMPLEX MAKIŠ

After the analysis of the present condition and the proposal of remedial measures, the preliminary concept of the picnicking-recreation complex should be designed, as the base for public tender for the main project, as well as the organisation of the public debate and the adoption of the concept, i.e. the preliminary project.

The concept of management should offer the preliminary solution for the construction of the "more urbanised park part with the composition of the highly impressive gardens, rich and diverse ornamental vegetation enriched with numerous contents of a "Tivoli" and a mini

“Disneyland“ which will gradually grade into a more natural ambiance of the forest-meadow and aquatic ecosystems with the terrains for numerous sports and recreation activities.

It is necessary to renew the old channel network or to construct the new one through the complex, which will be supplied with the filtered Sava water. The channels should be supplied with fish, which will be fished by many fans of angling and fishing.

Construct an artificial lake on 10-12 hectares which will be supplied with clean ground water. As the ground water is at a relatively small depth, the connection with the channel network is possible and the regulation of lake depth. The lake should be supplied with fish and the bank of the lake should be turned into beaches, so thousands of Belgrade citizens could go bathing during the summer period.

Along the channel, through the forest ambiance, walking paths should be constructed, and the channel should be bridged with wooden bridges and logs, to ensure unobstracted communications throughout the complex.

In the park-forest, construct numerous diverse playgrounds attractive not only to the citizens, but also to foreign lovers of the sports which are not traditional in our country, such as golf courses, polo, cricket and other attractive sports for recreation.

On the fitting location in the fringe part of the complex, establish a small-size horse farm with a dozen horses intended for horseback riding and driving for pleasure in a fiacre, with possible organisation of a riding school. Also, the bicycle renting service should be planned for those who enjoy bicycle riding through the woods.

Within the forest complex, form some small clearings for recreation activities in the forest, as well as walking and trim paths, which will create the conditions for more free movements through the park-forest, where each individual will feel unlimitedly free in his experience of psychophysical relaxation.

Design a “fiacre road“ length up to 15 km along the margin of the forest which could branch and lead to the most significant topics within the complex. In addition to fiacre driving, this road could also be used for horseback riding which would satisfy the lovers of horseback riding.

Along the “fiacre road“ bicycle paths should be constructed for undisturbed bicycle riding.

Taking into account the size of the picnicking – recreation complex with the above sport terrains, there are conditions for the construction of tennis courts, so our city - metropolis will have the conditions for the organisation tennis tournaments of a high rank, such as the tournaments in London, Paris, New York and other metropolises.

In the upper – upstream boundary part of the picnicking-recreation complex, construct a marina for yachts and for the fans of nautical tourism, as well as sailboats and tourist ships, and the river Sava and the banks should be freed from too many houses on water whose owners have privatised the bank and make it impossible for the anglers and other visitors to approach the river.

4. CONCLUSION

We have presented some of the multiple potentials of Makiš as the picnicking-recreation complex, which has all the preconditions to become more attractive than many of the known picnicking parks and park-forests of other capitals in the world.

If this projection is accepted by the authorised organs of the Municipality Čukarica, the City of Belgrade and the Republic of Serbia, it will be necessary first of all to undertake the research and analysis of the present status and to make the cadastre of the area by land use and ownership, the cadastre of residential, industrial and other buildings categorised by quality and their effect on the environment, the cadastre of the existing infrastructure, with special reference to poor condition and non-hygienic objects, and the direct polluters of the air, soil and ground water.

After the present status is evaluated and the cadastre is completed, it is necessary to make the proposal of remedial measures, not only technical-technological procedures of eliminating the undesirable objects, polluters and those that cannot be left within the picnicking-recreation complex, but also simultaneously a method of solving the social and other problems should be proposed, because numerous buildings should be eliminated, especially the polluters of the environment. A significant number of inhabitants, legally or illegally settled within Makiš area, should be moved. Private holdings and private lands within the complex should be purchased, in order to avoid the problems during the elaboration of the project and the construction.

The research and analysis of the present state with the proposal of the remedial measures has already been started by the Institute of Forestry in Belgrade with the cooperation of the Faculty of Forestry in Belgrade, as they have good-quality scientific and professional staff in forestry, landscape architecture, geodesy, soil science, hydrology, phytocoenology and other specialists. If needed, external collaborators can be engaged, top experts of the necessary profiles.

When all the projected contents are fully completed, the picnicking-recreation sport centre Makiš will be a pearl of tourism of our metropolis and its tourist brand.

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SECTION 8

GENE POOL CONSERVATION AND FOREST SEED PRODUCTION

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Abstract: *Conserving forest gene pool is vital. In forestry the quality of offspring plants improved populations will result if the seed used to produce them was collected from superior stands and individuals. The benefits of using quality seeds, chosen from selected parent trees, are twofold, improved survival and greater economic returns. The first step in forming a seed object is to select and mark the seed trees. These should be fast-grown healthy dominants capable of producing wood of good quality. The number and relative superiority of the seed trees marked have an important effect on the genetic improvement of the progeny raised from the seed collected in the seed stand. More precisely, the genetic gain or change in the average genotype of the population produced by the selection of seed trees depends on the heritability of the characters for which selection is made, the variability of these characters and the proportion of the population selected.*

To maximize yields and quality of seeds, the new aproach for seed production – exploitating DNA variability, multivariate statistics analysis and population genetic analyses – will be presented and discussed.

Key words: gene pool, population, forest tree seed, genotype

"In the beginning God created the heavens and the earth... and light, and water...and on the third day the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after his kind: and God saw that it was good." (Moses: The Book of Genesis)

A well-organised production and supply of tree seeds on the domestic market does not exist (information provided by the Ministry of Agriculture, Forestry and Water Management - Group for Forest Seeds, and by the Dendro-department of the Garden Centre). According to the Reports by SE "Srbijašume" (1995, 1997 and 2001), seed forests in Serbia do not at all satisfy the needs of seed and planting material production for the purposes of afforestation (SE Srbijašume, 2001). The still unrealised production plan of Srbijašume's seed orchards from 1997 predicted the annual production of 31,000 kg of forest seeds (490 kg of coniferous seed and 30510 kg of broadleaf seed) both for the export and for domestic needs till 2010. Also, the Spatial Plan of Serbia predicts the enlargement and enhancement of the growing stock, the afforestation of 2,445 km^2 only in central Serbia till 2010 (244,500 h a, which represents millions of seedlings). There are demands for afforestation in our country and worldwide, by all means, but only with good-quality seedlings – and they are the plants produced primarily by the good-quality seeds (The Production of Forest Seeds and Plants in Québec, 2003).

Seed qualities, especially its hereditary characters, are the most important for the success of nursery production and for the general success of afforestation. In sexual reproduction of higher

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plants, after the process of micro- and macro-sporogenesis, cells are formed in the process of micro- and macro-gametogenesis. In the process of sporogenesis during meiosis, the key factors take place, i.e. for understanding the inheritance, heritability and variation – diversity (reduction of a double to a single number of chromosomes (2n – n), random division of maternal and paternal chromosomes and the redistribution of the heritability material within the homologous chromosomes). The union of spermatic nucleus and the egg cell nucleus represents the central moment of fertilisation in plants (a double number of chromosomes (n-2n) is established, material relationship and the continuation of successive generations are formed, and the maternal and paternal genes are united into one individual).

Based on the multiannual research of diversity and gene pool conservation, and using the pilot example of Serbian spruce, this study proposes a new and original method of production of high-quality forest tree seeds, created by the combination of the DNA analyses, multivariation statistical analyses, population genetics methods and GIS tools.

What is the traditional method of production good-quality seed like?

Method One: In a forest complex, by mass selection, single out smaller parts, named seed stands. The disadvantage is that there is **no information on the genotype** of individual plants, because the selection is based on phenotype characteristics of the stand, which could have been formed under the exceptionally favourable environmental conditions.

Method Two: In a forest complex, „plus" trees are singled out by individual selection, with the control of their genetic constitution. The disadvantage is that the control is usually by testing the vegetative and (or) generative progeny, which requires long-term systematic research (min. 2 years). Plus trees are incorporated in the isolated plantations, so-called seed orchards. Their establishment is a **long-term undertaking** which lasts for years (Tucović, 1985). It is an anthropogenic system similar to agrosystem, instead of using the wealth originally offered by the forest ecosystem (Figure 1).

Figure 1. Traditional system of good-quality seed production

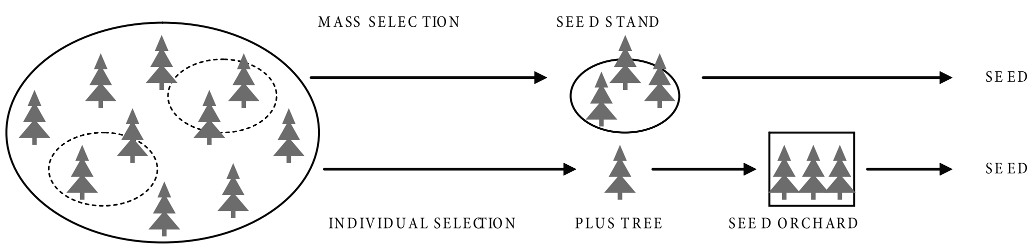
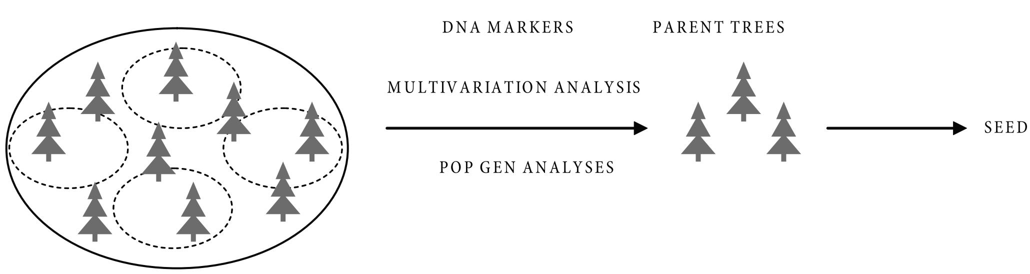


Figure 2. The proposed innovative system of seed production



What is the proposed innovation method of good-quality seed production like?

We propose a more efficient (more reliable and faster), original and modern procedure (exploitation of DNA polymorphism in combination with multivariation statistical and population-genetics analyses). By using GIS tools, by covering the largest possible range of species (Nevenić, 2004), by using biochemical and molecular markers (Ribeiro *et al.* 2002, Bojovic *et al.* 2005) we **directly obtain the information on the genotype**, research the genetic polymorphism of the populations (recognise the populations of high genetic variation) and within them, we select the individual parent trees. The procedure is much more efficient, reliable and **manifold faster** (Figure 2).

The Law on reproductive material of forest trees (Official Gazette RS, No. 135/2004, 8/2005) (harmonised with EU regulations) *inter alia* regulates the trade and categories of the initial and reproductive material. Pursuant to this Law, based on the original procedure of "genetic assessment" which is proposed in this study, both parent trees and seeds can get the highest category. The initial material (parent trees) can be recognised as the "initial material for the production of tested reproductive material", and the reproductive material (seed) can get the blue label and the title "tested (varietal) reproductive material" because it is obtained based on the fundamental genetic analyses (seed of high genetic quality and diversity) (without classical tests lasting for minimum 2 years). The protection of intellectual property will be regulated pursuant to the European law on intellectual property right (89/104/EECT2 1989).

Picture 1. Packed final product. Genetically certified high-quality seed of Serbian spruce, produced in the region which belongs to the only remaining natural site of this species in the world.

The starting ground for the selection of individuals for the production of high-quality Serbian spruce seed is the estimate of its genetic diversity in its natural populations – for this reason Serbian spruce is taken as the pilot example, as the endemic-relic endangered species with a very narrow range. Today, only about thirty populations remain in the middle and the upper course of the river Drina and in the Canyon of the river Mileševka, in the area which is practically bordered by the sides of a square (100 x 100 km). Kuittinen *et al.* (1991) estimate that natural populations of Serbian spruce in Serbia have a considerable genetic potential, i.e. that the genetic drift due to a low number of individuals does not have a great effect on the value of genetic diversity in its range. The assessment of genetic diversity in our project was performed by even more reliable co-dominant DNA markers, by micro-satellites (*paper in preparation*). The production units are unique natural populations of Serbian spruce which exist only in this region and nowhere else in the world. Based on the assessment of genetic parameters, the populations are identified which bear the maximum genetic information of the species and in them a minimal number of trees will be determined, sufficient to conserve the **maximum of the gene pool of the species**. This number of individuals means the number of plus trees which will be utilised for the regular collection of cones.

Seed is collected starting from October to March of the following year, but due to the weather conditions, it is beset to finish the harvesting till the end of December of the current year. The seed yield varies from year to year, there are years of abundant and low seed crop. It is estimated that the average number of cones per one adult tree is about 500. On average, 1 kg of seeds (5000 cones) can be harvested from 10 trees. The price of Serbian spruce seed on the world market is about 1000 Euro/kg. However, this seed is not from natural populations, but from Serbian spruce plantations in Germany and in the Scandinavian countries. The only seed from natural populations of Serbian spruce is the seed from the region in Serbia which is divided with the Republic of Srpska (Bosnia and Herzegovina). It is this seed that is the most interesting for the reconstruction of the sites of potential vegetation, for the production of good-quality seedlings, for afforestation, and for the improvement of spaces and landscapes.

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BIODIVERSITY OF MT. STOL – THE BASE OF THE ASSESSMENT OF ITS BIOCOENOSIS CONSERVATION

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Abstract: *Mt. Stol (1156 m) is situated in the Carpathian part of East Serbia. The diverse ecological conditions, uninhabitedness and a relative isolation of this area result in the great wealth of biodiversity on a relatively small space.*

The study of Mt. Stol living beings points to its specificity and to a low anthropogenic impact. The Spatial Plan of the Republic of Serbia till 2010 designates Mt. Stol as a significant area from the aspect of natural values, which makes possible its inclusion in the official protection programmes.

This paper presents the previous research of Mt. Stol biodiversity, with special reference to the significant, endangered, rare and endemic species.

Key words: biodiversity, biocoenosis, Mt. Stol, protection

1. INTRODUCTION

The area of East Serbia is specific, thanks to its position, relief and ecosystem diversity of flora and fauna, with a great number of endemic and relic species. The composition and richness of its fauna originate from the geological history. Unfortunately, both the faunistic and the floristic components have not been sufficiently and equally researched in all parts of East Serbia.

During the Upper Cretaceous, East Serbia was partly the land and partly the sea. Due to the tectonic movements by the end of the Mesozoic, the entire area became land. It was at first connected with the huge Pontic-Caspian lowland, from which steppe species invaded till the end of the Neogene.

From the middle of the Tertiary till the Neogene, the land of the present Timočka Krajina was the northernmost part of Aegeida. In the Pliocene, Aegeida was connected with Asia Minor, wherefrom the montane species especially, colonised the Balkan Peninsula and this part of Timočka Krajina. In addition to fauna, the elements of the Tertiary flora are also well known in the area of East Serbia, particularly from the Miocene and Pliocene.

The tectonic movements in the Tertiary upthrusted the land of East Serbia in the huge mountain wreath, today known as Carpatho-Balkanides. During the Glacial epoch, the Northern, frigoriphilic elements penetrated into a part of this area. During the Postglacial, the Northern elements retreated and thermophilic species penetrated from the South and Southeast (11). The elements of the Carpathians and the Rhodopes penetrated from the direction North – South of the mountain massif; the elements of the Pannonian area came from East margins of the Peripannonian plain, and the elements of the Pontic-Caspian area penetrated by the Danube valley from the East. All the above changes conditioned the diversity and richness of the living organisms.

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Goli Krš and Stol are one of the three limestone ridges in the Gornjanski karst relief. Some short ridges and rocky lands were tectonically and morphologically separated in the vicinity Mt. Stol. Mt. Stol (1156 m) is in the Carpathian part of East Serbia. Its bedrock is made of limestone layers and represents a horst upthrown area, with the layers sloping towards Southwest, slope up to 40°. This massif lies on the bedrock made of Precambrian rocks, the oldest rocks in Serbia and the entire former Yugoslavia (2). The area of Stol and its surroundings is approximately about 100 km^2. In the West, Stol is surrounded by a mountain massif of Veliki and Mali Krš. In the UTM network, this area is in the field EP 99.

Jovan Cvijić visited the Stol area several times, starting from 1893. He reports: "Sto has a trapezoid profile form; it looks like a huge and clumsy mountain... Its horizon is one of the widest horizons in East Serbia." Cvijić also stresses that Stol with Veliki Krš makes the longest limestone ridge in East Serbia (1).

2. FLORISTIC AND FAUNISTIC RESEARCH OF MT. STOL

The diverse ecological conditions, uninhabitedness and relative isolation of Mt. Stol conditioned the great wealth of biodiversity on a relatively small space.

Along the margin of this limestone massif, there are numerous karst springs, of which some are tapped for water supply of Bor and the surrounding villages. The ground water is clear, colourless, odourless and tasteless. This is low-mineralised water which belongs to the calcite group of hydrocarbon minerals. By its physico-chemical characteristics, the karst ground water of the limestone massif Stol and Veliki Krš is categorised as 1st class water (3). In the ridge foothill, at the altitude of 850 m, there is a storage 'Stol', length 100, width 25 m. It was constructed in 1970 by building an embankment in the aim of erosion control (4). The limestone ridge Stol is characterised by dry conditions.

The area of East Serbia in general has a very characteristic composition and representation of plant species. The favourable ecological factors support the development of numerous plants, but also the survival of many relic and endemic species.

Based on the geographical position, the variation ranges of temperature and precipitation, the climate in this area is the transition between the steppe and Mediterranean climates, and the effect of the mountains (Diklić, 1967) gives Mt. Stol vegetation a xeromorphic character.

From the biogeographical aspect, Udvardy, M. D. (1975, 2000) classifies this area as the ecosystem type of broadleaf forests of the temperate area in the bio-geographical province of the Balkan uplands. Matvejev, S. (1989) accepts the map of Yugoslavia natural potential vegetation as the base, and he classifies this area within the biome of the South European broadleaf forests. According to Hadži's (Hadži, J., 1935) zoo-geographic classification of Yugoslavia, this area belongs to the Moesian province (Jakšić, 2005).

However, Mt. Stol biodiversity has been insufficiently and only fragmentarily investigated. The results of previous researches presented in this paper reveal the richness and specificities of the living organisms of Mt. Stol.

Just as in other limestone massifs in East Serbia, a diverse, secondary meadow-pasture vegetation developed at places where forest plants have disappeared, and these areas have the characteristics of Sub Mediterranean and Mediterranean karst landscapes (6).

Plant cover consists of thin forests, meadows and pastures. This area has not been floristically researched in detail, and only individual data on its vegetation are available.

The significant findings of flora on Mt. Stol reported in the monograph 'Bor and Its Surroundings' (Diklić, Nikolić, 1975) are the species: *Edrayanthus serbicus* (Kern.) Petrović, *Achillea ageratifolia* var. *serbica* (Nym.) Hayek, *Eryngium palmatum* Vis. et. Panč., *Hypericum boissieri*

Petrović, *Hyacinthella leukopaea* (Stev.) Sehur. Jovanović (1996) reports the finding of the species *Sesleria regia* and 3 endemic species: *Potentila chrysanta*, *Euphorbia ilirica* and *Cerastium banaticum*. On the south exposure, the same author found the plants of steppe character, such as *Carex pumilis* and *Potentila cinerea*. Niketić (2005) reports the rare *Saxifraga moschata* on Stol.

The forests on Stol are: forest of beech (*Fagus sylvatica*) and Turkish hazel (*Corylus colurna*), with low communities of Venetian sumac (*Cotinus coggygria*), lilac (*Syringa vulgaris*) and oriental hornbeam (*Carpinus orientalis*). The storage 'Stol' is surrounded by mesophilic meadows, which border on the beech forest, and which change into xerophilic ones with increasing elevation.

Fabri *et al.* (2001) researched some meadow plant communities in this area. Meadow communities of Mt. Stol develop in different site conditions of water regime. The flora of the study area has a marked hemicryptophyte character, with a low general percentage of trophytes, which indicates both the stability of the meadow plant communities, and the low anthropogenic impact (6).

Stol is characterised by the biotope diversity in a small area. Going from the foothill towards the peak, there are different sites, with different temperatures and water regimes: first, it is the mountain foothill rich in limestone aquifers, thin forests of beech, as well as forests of beech and Turkish hazel with a denser canopy, then brushland with Venetian sumac and lilac, then mesophilic and xerophilic meadows and pastures and finally the limestone ridge Stol, manifestly dry. The anthropogenic impact in this area is low.

In the reservoir "Stol", Reh (1996) found 30 species of *Rotatoria.* Based on the identified species, he concluded that the mean saprobic index of the reservoir "Stol" was 1.73, which classifies the analysed water in β-meso-saprobic (2nd class). Ratajac *et al.* (1999) identified 4 species of *Cladocera*, and 9 species of *Copepoda*. *Hydracarina* were represented by three species.

The snail fauna (*Gastropoda, Mollusca*) was investigated several times by Jovanović (1989, 1995) from the Natural Museum in Belgrade, who identified altogether 37 snail species on Stol, of which 4 are endemics. They are: *Bulgarica stolensis* (Pfeifer, 1859) – endemic in Serbia (the species was named after Mt. Stol, where scientist Pfeifer found it and described it in 1859), *Macedonica frauenfeldi frauenfeldi* (Rossmassler, 1839) – endemic of Serbia, *Helicigona kollari* (Pfeipfer, 1856) – endemic of Serbia and *Argna parreyssii* (Pfeifer, 1848) – endemic of the Balkans (Jovanović, 1996, 1998, Karaman,1999).

The spider fauna (*Araneae)* is insufficiently studied, only a few species are identified from Stol: *Dicymbium tibiale* (Blackwall, 1826), *Argiope bruennichi* (Scopoli, 1772), *Cybaeus angustiarum* L. Koch. Of these species, the most interesting is the wasplike spider, *A. bruennichi* (Scopoli, 1772), a typical Mediterranean species (Deltshev *et al.*, 2003).

The insect fauna was researched by several authors. However, many insect groups have not been researched. We shall only present the data on some rare, endangered, or endemic insect groups: plant bugs, thrips, butterflies and beetles.

The bugs (*Insecta, Heteroptera*) were studied by Protić, who reports several significant findings. First of all, the finding of the species *Eurydema gebleri* (*Heteroptera, Pentatomidae*). The centre of its range is Asia, and the finding on Stol is the only finding of this species from the Balkan Peninsula (Protić, 1997). Another significant species of *Heteroptera* from Stol (Protić, 1994) is: *Calocoris princeps* Reuter – a rare species and a Balkan endemic. Its finding on Stol is the Northernmost point in its range of distribution on the Balkan Peninsula. The species *Placochilus seladonicus* Fallen identified from Stol represents the first finding of this species in Serbia. The species *Sternodonotus obtusus* Mulsant & Rey, otherwise widespread in the Mediterranean, represents the first finding from the area of the former Yugoslavia.

Andjus (1990) reports two significant species of thrips (*Insecta, Thysanoptera)* from the Stol area: *Thryps treharnei* Priesner, 1926, which was found on another three localities in Serbia

(Rtanj, Prova and Divčibare) and *Haplothrips alpester* Priesner, 1914, whose finding on Stol is the only finding in Serbia.

The *Lepidoptera* fauna in this area has been especially well investigated during multiannual activities by several authors (Radovanović, Zečević, Jakšić, Stojanović, Randjelović, *et al.*).

More than 100 species of diurnal butterflies (*Lepidoptera: Hesperioidea* and *Papilionoidea*) are identified in this area, and the significant findings are: *Esperarge climene* - rare species (according to IUCN, it is R category) in Serbia, protected by the new Decree on the protection of natural rarities 2002, found in Serbia only on Stol (Jakšić, 2003), *Papilio machaon* - endangered species (E) in Serbia, protected by the Decree on the protection of natural rarities 1993, 2002, *Euchloe ausonia* - endangered species (E) in Serbia, protected by the new Decree on the protection of natural rarities 2002, *Zerynthia polyxena* - vulnerable species (V) in Serbia, protected by the Decree on the protection of natural rarities 1993, 2002 , *Parnassius apollo* - vulnerable species (V) in Serbia, protected by the Decree on the protection of natural rarities 1993, 2002, *Colias myrmidone* - vulnerable species (V) in Serbia, protected by the Decree on the protection of natural rarities 1993, 2002, *Parnassius mnemosyne* - protected by the Decree on the protection of natural rarities 1993. Thanks to the presence of numerous significant species at the European and national levels, this area has been designated as one of the most important habitats of daily butterflies in Serbia (Prime Butterfly Areas, Jakšić, 2003). Of nocturnal butterflies, the geometrid fauna (*Lepidoptera, Geometridae)* is especially interesting. Tomić *et al.* (2002) reports on the tens of species in this group from the researched area. *Isturgia roraria* Fabricius, 1776 is identified in Serbia only from Stol, *Dasycorsa modesta* (Staudinger, 1879) is identified in Serbia only from Stol and from Kraljevica, *Cabera leptographa* Wehrli, 1936 is identified in Serbia only from Stol, species *Eupithecia plumbeolata* (Haworth, 1809) is identified in Serbia only from Stol. The noctuid fauna (*Lepidoptera, Noctuidae*) is represented by a great number of species in the area of Stol (Vasić, K., 2002). The following are the findings of some significant and rare species: *Odice suava* (Hübner, 1813) from Stol, *Cucullia chamomillae* (D. und S., 1775), *Cucullia prenanthis* (Boisduval, 1840), *Enargia abluta* (Hübner, 1808), *Agrochola laevis* (Hübner, 1803), *Dasypolia templi* (Tunberg, 1792) and *Apamea crenata* (Hufnagel, 1766). Stojanović D. (2002) found three new species for the fauna of Serbia in the family *Noctuidae* from these localities. They are: *Orectis proboscidata* (H-S), rare Pontic-Mediterranean species, *Mythimna alopecuri* (Boisduval, 1840), rare Eurasian-Mediterranean species and *Chortodes fluxa* (Hbn.).

The beetles (*Insecta, Coleoptera*) have been researched by several authors. Nonveiller *et al.* (1999) in the monograph on *Cholevinae* group (Coleoptera*)* reported the data on seven species in this group found on Stol. Nonveiller (1983) reported on the new subspecies *Lathrobium anophtalmum ssp. stolence* (Pace, 1984). The species was found below the stones, in the belt of beech forest at the altitude of about 700 m on Stol. In the same paper, Nonveiller reported also the finding of another new species for science: *Egeotyphlus zecevici* (Pace, 1984), which was the second identified species in this genus in Europe. The genus *Egeotyphlus* had previously been identified only by one species - *E. thracicus* (Coiffait, 1957) from Greece. Another new species of beetles, *Nanophtalmus serbicus* Besuchet (in press), was identified on Stol and Rtanj and its description is underway (Nonveiller *et al.*, 1997). Another still undescribed new species was found on Stol: small carabide in the genus *Winklerites, Anillini*. The finding of the representative of this genus in East Serbia is surprising, because it was thought that the distribution of the species is limited to the Dinarid region (Nonveiller *et al.*, 1997). A rare *Coleoptera* from Stol was described by Dajoz. (1987) - the species *Anommatus schrotteri* Reitter. Đurić (2003) in his Master of Sciences Thesis summed up the existing data on the carabides (*Coleoptera, Carabidae*) in Serbia. The following species are listed: *Winklerites sp.* from Stol, *Trechus pulchellus ventricosus* Jeannel, 1921 from Stol and *Trechus quadristriatus* Schrank, 1781 from Stol.

The ornithology of Mt. Stol has been well studied and together with the area of Veliki Krš it is officially inscribed in the list of important bird area, i.e. IBA nac 88 (Puzović and Grubač, 1988). The first ornithological research of this area was performed by the famous ornithologist Otmar Raiser in 1900. Raiser (1904) named Stol 'an astonishing hill', and according to him, one of the specificities of Stol was the presence of the partridge *Alectoris gracea*, which has almost disappeared from the area of Northeast Serbia. The Mt. Stol ornitho-fauna was also researched by Matvejev (1950), who reported the presence of the karst falcon (*Falco biarmicus*), today one of the rarest birds of prey in Serbia (Puzović, 2000). Matvejev also mentioned the finding of the Mediterranean *Oenanthe hispanica*, which is one of the rare nesting birds of Serbia. The birds of Mt. Stol were also researched by Ham (1980). He emphasised especially the finding of *Coracias garrulus*, the species endangered at the international scale. He also reported the rare species, such as *Sylvia nisoria* and *Emberiza hortulana*. During the research of bird fauna in East Serbia 1990-93 Paunović and Puzović found on Stol a series of species significant at the national level, such as forest woodcock (*Scolopax rusticola*), gray falcon (*Falco peregrinus*) and mountain woodpecker (*Dendrocops leucotos*) (Puzović and Paunović, 1994, Paunović 1991, Puzović 1994, 2000, 2000a). An especially valuable element of Mt. Stol avifauna is the species *Accipiter brevipes* (Northtzov, 1850 which is listed in the "Atlas of the birds of prey in Serbia" (Puzović, S., 2000). The territory of East Serbia is the nesting place of more than 80% of all the birds of prey species identified in Serbia. The map of spatial distribution of the main centres of diversity of the birds of prey nesting in Serbia (15) indicates that the main centre of diversity of birds of prey in East Serbia is the area of Veliki Krš, Mali Krš and Stol.

Savić, Radović and Mandić (17) emphasise the area of Mali Krš and Veliki Krš as the centres of diversity of vertebrates in Serbia (which also includes Stol). They also propose the extension of the existing network of protected areas to the selected centres of vertebrate diversity. In this area, Petrov (1992) reported the findings of 3 species from the group of small mammals, *Insectivora*: *Erinaceus concolor, Sorex araneus, Crocidura suaveolens*, and 7 species from the group of *Rodentia*: *Clethrionomys glareolus, Pitymys subterraneus, Microtus arvalis, Apodemus flavicollis, Apodemus sylvaticus, Rattus norvegicus, Mus musculus.*

The wealth and significance of biodiversity of such areas is dealt with in the book 'Biodiversity of Yugoslavia with the survey of species of international significance', where it is written: `Bearing in mind the relatively small space of the (Eu)Mediterranean biome and steppe - forest-steppe formations ......all the territories with the conserved elements of these ecosystems (with the characteristic thermophilic fauna) should be considered as the centres of diversity of the local (national) significance, because they also support a series of species which are mainly absent in the mentioned centres of great faunistic richness' (18).

There was another attempt of determining the centres of biodiversity in the area of Carpathian Serbia. Within the Project 'Development of Information System on Carpathian Biodiversity' (20) the information system was developed for the collection of data on biodiversity in the Carpathian region of Serbia (divided into 11 oro-geographical units) to identify the priority areas of significance for biodiversity protection, based on the existing data. The locality Stol is classified within the orographic unit Mali Krš and Veliki Krš.

The collection of data and their evaluation was performed by CEI method, which determines the areas of priority significance for biodiversity protection (WWF 2001). In short, the key species and communities of significance for the Carpathian region were listed and then the list was modified for the Carpathian area in Serbia. The data on the distribution of these species were entered in the data base of the Geographical Information System (GIS), based on which the map of species distribution was constructed. The centres of biodiversity in the area of Carpathian Serbia were identified by overlaying the resulting individual maps.

The orographic unit Mali Krš and Veliki Krš, by this method, belongs to the area of conserved biodiversity. However, mainly due to the shortage of data on some key species distribution, it has not yet been assigned the priority significance. Further floristic and faunistic research of this area would, by all means, contribute to its priority in the area of conserved biodiversity in the Carpathian region, which is of priority importance for its protection.

3. CONSERVATION OF BIOCOENOSES AND THE PROTECTION OF MT. STOL

Biocoenosis represents the biological system consisting of the populations of different species of plants, animals, fungi and microorganisms, formed as the result of long-term and comparative ecological processes. The qualitative composition of the biocoenosis represents the presence and the combination of the represented species. The successful migration of a species, i.e. its fitting in the biocoenotic structure, depends on the stability and the level of self-sustainability of the biocoenosis.

The essential role in the structure and physiognomy of the biocoenosis belongs to the plants, which are the base of any biocoenosis, making the precondition for the survival of all heterotrophic organisms in it. Consequently, despite the insufficient research of Mt. Stol flora and vegetation, based on the wealth of the better researched groups, for example insect group *Lepidoptera* which is very well researched on Mt. Stol, it is possible to make an indirect conclusion on the occurrence, diversity and conservation of plant formations in this area.

Considering the connection of all the elements of the biocoenosis, based on the food chains of the coenobiont trophic types (producers, consumers and reducers) and the well-known rule on the lower abundance of species which are at the apex of the trophic pyramid, based on the data on the diversity and populations of consumers of the highest trophic order, it is possible to draw some conclusions on the richness of an area. On the example of Stol and the surrounding area, this can be illustrated by the data that these landscapes are considered some of the greatest centres of diversity of the birds of prey (both by the number and by the species density in Serbia (15).

The richness of species is proportional to the diversity of sites and micro-climate conditions occurring in an area, as well as to the conservation of the balance of biocoenoses inhabiting the sites.

The previous study of Mt. Stol plant and animal life prove its conservation, uniqueness, specificity and a very low anthropogenic effect, although this area is near the industrial combinate of the copper mine Bor. Consequently, it can be concluded that the potential disturbance of any link in the function of biocoenoses on Stol by complex coenotic relations in the food chain, would be reflected on all other links in the system.

The area of Stol and the surrounding limestone ridges, Veliki and Mali Krš, have so far been proposed several times for the Protection regime by different aspects, both by the domestic and by foreign scientists-researchers, and also by local ecological associations.

The Spatial Plan of the Republic of Serbia till 2010 designates the Stol area as significant from the aspect of conservation of natural values, which makes the conditions for its inclusion in the official protection programmes. Lješević, Filipović (1998) in their survey of the existing and planned protected areas on the territory of the Republic of Serbia, designate it as valuable from the standpoint of recreation and ecotourism. However, it has not been included in the latest map of the present and future protected areas in Serbia. This paper shows that Mt. Stol area has a significant value of geo- and bio-diversity. Therefore, we hope that, in the near future, it will be included in the protected areas by the state.

4. CONCLUSION

Although the biodiversity of Mt. Stol area has only fragmentarily been researched, the results presented in this paper point to the richness and specificity of the living beings in this area. This is emphasised by the fact that Stol is in the list of the areas of special national significance for bird fauna (IBA nac 88), with special emphasis on the biodiversity of birds of prey. Some authors designate the area of Stol and its surroundings as one of the centres of vertebrate diversity in Serbia (17). Within the Project 'Development of Information System on Carpathian Biodiversity' this area is designated as one of the areas of conserved biodiversity in the Carpathian Serbia.

Several species from different animal groups have been identified as new to the fauna of Serbia, and even the Balkans, 3 new species from the order of *Coleoptera* are new to science and one from the class *Mollusca*, there are several endemics of Serbia and the Balkan Peninsula, as well as a great number of typical Mediterranean species. The wealth of taxa in this area points to the conservation of the balance of biocoenoses, as well as to the diversity of the dominant site conditions.

The study of plant and animal life of Mt. Stol proves its specificity and the low anthropogenic impact. Taking into account the relative vicinity of the industry of the copper mine Bor and the real hazard by the anthropogenic factors, in accordance with the above, the importance of biodiversity conservation on this area should become the priority.

For this reason, we would like to emphasise the significance of the additional floristic and faunistic studies of Mt. Stol in the aim of the urgent procedure of valorisation and designation of the adequate protection regime by the responsible institutions.

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SECONDARY REGENERATION FROM SOMATIC EMBRYOS OF *AESCULUS CARNEA* HAYNE

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Abstract: *Somatic embryos of red horse chestnut were subjected to an induction of secondary regeneration. The embryos were divided in 4 classes on the basis of their size (I-1, II-5, III-10 and IV-30 mm), and sub-cultivated on MS media containing 0, 1, 5 or 10 µM kinetin (Kin) or benzyladenine (BA). The pathway of secondary regeneration (somatic embryogenesis or caulogenesis) depended solely on the primary somatic embryo (PSE) stage of development. The PSE of the I and II class produced solely secondary somatic embryos (SSE), the III class PSE formed SSE on media containing Kin, and both SSE and adventitious buds on media containing BA, whereas the IV class PSE developed almost solely adventitious buds. BA promoted bud induction at much higher rate than Kin and slightly higher embryogenic response. The histological study confirmed these findings.*

Key words: adventitious buds, red horse chestnut, secondary somatic embryos

1. INTRODUCTION

Somatic embryogenesis is the process of an embryo formation from a somatic cell(s). Somatic embryos (SE) induced from primary somatic embryos (PSE) are called secondary somatic embryos (SSE) or adventive embryos. The process is usually repetitive and thus also called repetitive or recurrent somatic embryogenesis. This character enables embryogenic capacity maintenance by repeated cycles of secondary embryogenesis over a long period of time (Raemarkes *et al.*, 1995). Secondary somatic embryogenesis has been reported in a number of woody species, including related horse chestnut (Dameri *et al.*, 1986; Radojević, 1988; Kiss *et al.*, 1992; Jörgensen, 1989). The influence of plant growth regulators (PGR) on horse chestnut secondary somatic embryogenesis was studied in details using scanning electron microscopy by Kiss *et al.* (1992) and Ćalić *et al.* (2005). Kiss *et al.* (1992) found a distinct correlation between the embryo-forming capacity and the PSE size. They found that the PSE of 8-10 mm were optimal for SSE induction, whereas those reaching 12-14 mm lost the SSE forming capacity. The process was independent of the origin of the PSE (zygotic or somatic). The presence of adventitious buds was not reported. Another morphogenetic pathway, caulogenesis, is the process of adventitious bud formation. As it demands a root-inducing step, this kind of regeneration is assumed to be inferior to somatic embryogenesis. However, somatic embryogenesis and caulogenesis are frequently simultaneous within the same explant (Budimir, 2003/4).

In *Aesculus carnea* androgenesis through anther culture and subsequent haploid plant regeneration were achieved (Radojević *et al.*, 1989). The aim of the current study was to examine

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a correlation between the stage of PSE development and the process of secondary regeneration (somatic embryogenesis and caulogenesis).

2. MATERIALS AND METHODS

SE of *A. carnea* were induced from androgenic embryos obtained according to previously described procedures for *A. carnea* anther culture (Radojević *et al*., 1989) and *A. hippocastanum* microspore suspension culture (Ćalić *et al*., 2003/4). The SE cultures were maintained through repetitive somatic embryogenesis on solid MS medium containing 0.01 mg/L 2,4-D + 1 mg/L Kin.

The basal medium contained the following: MS mineral solution (Murashige and Skoog, 1962), 2 % sucrose, 0.7 % agar, 100 mg/L myo-inositol, 200 mg/L casein hydrolysate, 2 mg/L thiamine, 2 mg/L adenine, 5 mg/L nicotinic acid, 10 mg/L panthotenic acid. The cultures were maintained under cool white fluorescent tubes with fluency rate of 33-45 μmol m^{-2} s^{-2} and a 16 *h* photoperiod, at 25 ± 2 °C. The media were sterilized by autoclaving at 114 °C for 25 min.

The PSEs of different size at different stage of development (globular, cotyledonary, germinating embryos) were used for the current experiment. They were divided in 4 classes based on their size (I-1, II-5, III-10 and IV-30 mm), and sub-cultivated on MS media containing 0, 1, 5 or 10 μM Kin or BA. At least thirty PSE were used for each treatment, in six replicates with five sub-samples. Experimental design was completely randomized block design. The numbers of SSE and adventitious buds were recorded after 4 weeks by dissecting the PSE and counting the number of secondary regenerants (SSE or adventitious buds) under stereomicroscope. The results are expressed as the percentages of PSE forming secondary regenerants and the mean number of secondary regenerants per PSE.

3. RESULTS AND DISSCUSION

SE of *A. carnea* were induced from androgenic embryos. The SE cultures have been maintained through repetitive adventive embryogenesis on solid MS medium containing 0.01 mg/L 2,4-D + 1 mg/L Kin for a few years. Adventitious buds were never noticed. When germinating SE were placed on media containing BA, the occurrence of adventitious buds was apparent. We tested the effects of media containing Kin or BA at 0, 1, 5 and 10 μM and found no differences in the type of regeneration present. However, when we utilized embryos of different size, the differences in the morphogenic pathway became apparent. The smallest PSE (I and II class, 1 and 5 mm) produced solely SSE, the III class PSE (10 mm) formed SSE on media containing Kin, and both SSE and adventitious buds on media containing BA, whereas the IV class PSE (30 mm) developed almost solely adventitious buds. This is in agreement with Kiss *et al*. (1992) who reported on the loss of the embryo-forming capacity of PSE bigger than 12-14 mm in horse chestnut. When the I and II class SE were placed on the induction media, only a slight proliferations of epidermal layer could be seen during the first two weeks. The highest activity was in the radicle, especially at the base and the tip of radicle (Figs. 1 and 2). These proliferations usually peeled off, and SSE emerging from them could be seen all around the PSE within the next week. The same region (radicle) was the most active in the IV class PSE, although in this case adventitious buds were formed (Fig. 3). Within the IV class PSE, activity of the superficial layer became apparent after a few days. Epidermis burst, but no visible callus was formed. Green regenerants were observed after ten days (Fig. 4), mainly on the radicle, and only seldom on the cotyledons (Fig. 3). As the PSE grew, the radicle elongated and formed the root. Secondary roots formed abundantly at 1 μM Kin or BA, whereas at 5 and 10 μM Kin or BA the roots began to thicken. From root's epidermal and sub epidermal layers voluminous white-snowish callus formed, without any form of regeneration. After removal of this callus, small nodules emerging from the inner tissues with tightly bound green regenerants were observed starting from the third week.

Spontaneous formation of SSE on PGR-free medium was observed within all classes, being maximal within the II and III dass (40 % both, means 9.4 and 11.7),but in the IV dass SSE occurred only on 8 % of PSE (mean 1.0 SSE) (Table 1). However, adventitious bud formation occurred only in the IV dass PSE at 36 % (mean 3.3). Our results are in accordance with the results of Ćalić *et al*. (2005) who showed spontaneous SSE formation in horse chestnut androgenic embryos on PGR-free medium. The highest embryogenic response of PSE (70 %) was reached at 5 µM Kin within the II PSE class, and maximal SSE number per PSE (32.7) was recorded at 10 µM BA, within the III class (Table 1). The maximal organogenic response (100 % and 96.30 %) of PSE and maximal bud number per PSE (48.8 and 68.8) were achieved at 5 and 10 µM BA respectively, within the IV PSE group (Table 1). Higher cytokinin concentrations were not tested due to high hiperhydricity that was already present at 10 µM.

The histological study was undertaken to confirm these findings. Paraffin sections through the IV class PSE revealed the meristematic zones embedded in calli, with obvious connection with the maternal tissue (Fig. 5). These structures developed into more advanced bud forms (Fig. 6). SSE were seen only occasionally on these sections.

Figs. 1 - 6. Secondary regeneration from somatic embryos of Aesculus carnea. 1. and 2. – Secondary somatic embryo (SSE) formation at the root pole of the II class primary somatic embryo (PSE). 3. – Adventitious bud regeneration from the radicle of the IV class PSE. 4. – Adventitious buds emerging from the radicle of the IV class PSE. 5. – Meristematic zones embeded in callus from the radicle of the IV class PSE. 6. – An adventitious bud regenerated from the IV class PSE radicle.

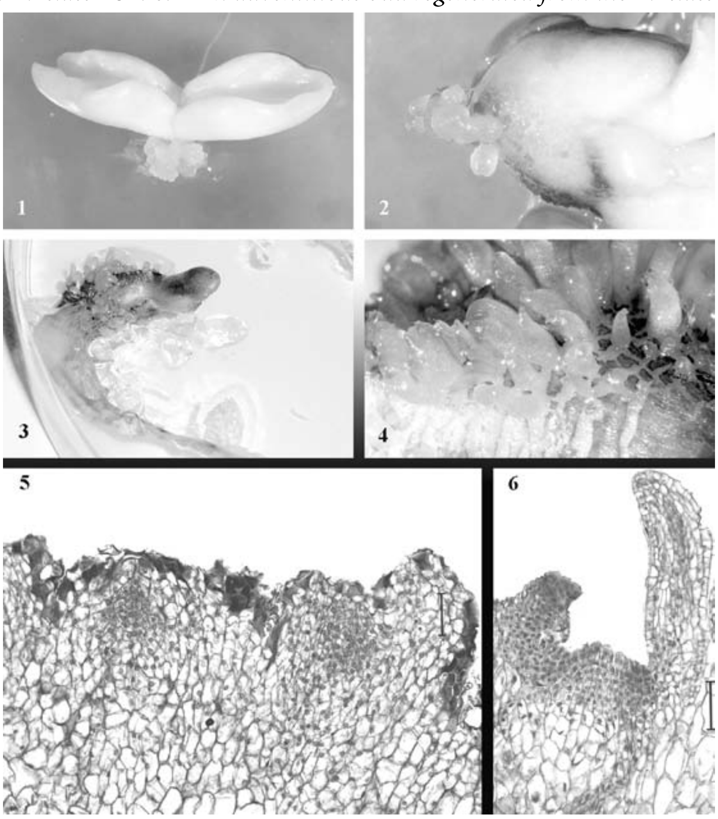

Table 1. Secondary somatic embryo (SSE) and adventitious bud formation from the primary somatic embryos (PSE) of Aesculus carnea at different stages of development.

PSE class	Kin (μM)	BA (μM)	% PSE with SSE	Mean SSE	% PSE with buds	Mean buds
I 1 mm	-	-	9.1	17.3de	0.0	0.0a
	1	-	30.0	7.3c	0.0	0.0a
	5	-	60.0	10.0d	0.0	0.0a
	10	-	20.0	9.5cd	0.0	0.0a
	-	1	50.0	7.2c	0.0	0.0a
	-	5	60.0	20.2e	0.0	0.0a
	-	10	20.0	3.0bc	0.0	0.0a
II 5 mm	-	-	40.0	9.4cd	0.0	0.0a
	1	-	30.0	29.0f	0.0	0.0a
	5	-	70.0	12.0d	0.0	0.0a
	10	-	50.0	19.2e	0.0	0.0a
	-	1	20.0	22.5ef	0.0	0.0a
	-	5	30.0	18.3e	0.0	0.0a
	-	10	40.0	8.7c	0.0	0.0a
III 10 mm	-	-	40.0	11.7d	0.0	0.0a
	1	-	0.0	0.0a	0.0	0.0a
	5	-	10.0	11.0d	0.0	0.0a
	10	-	40.0	8.7c	0.0	0.0a
	-	1	0.0	0.0a	10.0	2.0b
	-	5	20.0	17.0de	40.0	23.5c
	-	10	30.0	32.7f	60.0	19.2c
IV 30 mm	-	-	8.0	1.0b	36.0	3.3b
	1	-	5.3	8.0c	21.0	2.2b
	5	-	0.0	0.0a	26.3	1.4b
	10	-	0.0	0.0a	64.3	5.0b
	-	1	10.5	1.0b	78.9	7.5b
	-	5	0.0	0.0a	100.0	48.8d
	-	10	3.7	14.0d	96.3	68.8e

Data within a column followed by a different letter are significantly different according to LSD test at P ≤ 0.05, n=30.

We assume that the differences in response at different stages of PSE development could be attributed to differences in the physiological status of the competent cells. The response was simmilar regardless of the presence of a PGR in a medium, the cytokinine type and concentration applied. The embryogenic potential of an explant is affected by numerous factors. The most important are: the level of endogenous hormones within the explant, the interaction between applied PGR and endogenous hormones, sensitivity of the explants to PGRs, PGR uptake levels etc. (reviewed by Jiménez, 2005). Although there was no clear correlation between endogenous hormone levels and SE induction among different species and general conclusions could not be drawn (Jiménez, 2005), many authors found levels of endogenous hormones to be one of the most important factors determining embryogenic potential of an explant (Fehér *et al.*, 2003; Gaj, 2004). Centeno *et al.* (1997) demonstrated that the embryogenic capacity of hazelnut cotyledonary explants declined with the degree of the zygotic embryo maturity. They found a correlation between embryogenic capacity and endogenous PGR content: 10-20 times higher iP-type/Z-type cytokinin ratio, and 5-10 times lower Z-type cytokinins/IAA ratio in embryogenic than in non-embryogenic explants. The loss of embryogenic potential of the germinating PSE could be caused by the reduction of endogenous ABA level. Prewein *et al.* (2004) found a reduction in ABA level during germination of somatic embryos. Higher levels of endogenous ABA were reported to favor somatic embryogenesis in many species (reviewed by Jiménez, 2005). Disturbing a native explant's physiological status, by applying polar auxin transport inhibitors, Charrière and Hahne (1998) demonstrated change in morphogenic pathway in *Helianthus annuus* from embryogenic to organogenic. There are numerous contributions stating that developmental stage of the zygotic embryo is critically important for SE initiation (Gaj, 2004; Park *et al.* 2006).

To conclude, we reported on the differences in response of the primary somatic embryos of *A. carnea* depending on the stage of development. The PSE of up to 10 mm formed SSE, whereas bud formation prevailed from the germinating PSE. However, there were some differences between the effects of the two cytokinins. BA promoted bud induction at much higher rate than Kin and slightly higher embryogenic response.

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POLLEN EMBRYOGENESIS OF *SPP. AESCULUS*

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Abstract: *In the field of regeneration of plant in vitro cultures, haploid formation from pollen is the scientifically most advanced. In the present state of transition from basic research to commercial application, a sound scientific basis of pollen embryogenesis would make this transition much easier. New discoveries in recent years have made it possible to develop a new view of pollen embryogenesis. The new view includes recognition theoretical aspects, provides a model for a number of problems in plant development, and has consequences for strategies for haploid production. We developed a excellent model system for a mass production haploid regenerants of Aesculus hippocastanum, Aesculus carnea, Aesculus flava and Aesculus parviflora.*

Key words: anther culture, embryogenesis, haploids, pollen.

1. INTRODUCTION

Haploids had been known of for a long time before this discovery (Blakeslee *et al.* 1922) as had their potential uses in plant breeding and basic research (Blakeslee and Belling 1924). In the early days of plant tissue culture, any part of plant was put into culture including the anthers, the male sex organs. However, haploids from pollen opened a new dimension because of the abundance of pollen produced by the plants and their potentially general occurence in the plant kingdom, thus overcoming the limitations of other sources of haploids (Nitzsche and Wenzel 1977). In the case with other cultured organs, the results was not what was expected. Guha and Maheshwari (1964, 1966) wanted to study normal male sexual development, but what developed in their cultured anthers were not male sex cell (pollen) but embryos (Maheshwari *et al.* 1980, 1982). Thes e embryos developed into plants with a gametic (haploid) chromosome number.

With pollen embryogenesis, things were more complicated. There, the pollen to be cultured was immature from the beginning of experimentation, and paradoxically, one had to look into mature anthers in order to find a break-through.

Androgenic embryos (Radojević 1995, Radojević *et al.* 1998), such as the somatic embryos of horse chestnut (Jorgensen 1989) shown rapid differentiation and asynchronous development and maturation, like and low germination. It is necessary to provide optimal nutritive and enviromental conditions (Capuana and Deberg 1997, Radojević *et al.* 1998) and to overcome inhibitory effect, such as those coused by the presence of swollen cotyledons. Distinct developmental stages include the globular, heart-shaped, torpedo-like and cotyledonary stage of *Aesculus spp*. (Radojević 1988).

Under certain conditions, immature pollen or microspores from various plant species can be induced to form haploid embryos (Bhojwani and Razdan 1996). Guha and Maheshwari, first observed the development of haploid embryos, from anthers of *Datura innoxia* L., in 1964. The process of embryo induction from microspores has been reffered to as androgenesis (Bhojwani and Razdan 1996).

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In *B. napus* L., the microspore divedes to form two indentical daughter cells, and these in turn lead to development of the multicellular pollen grain (Bhojwani and Razdan 1996) in process orginally described as "pathway B" in pollen development (Sunderland and Dunwell 1974). Induction of androgenesis can be viewed as the redirection of pollen formation to that of haploid embryo development. The age of the developing pollen grain has been found to be crucial in the induction of androgenesis with the late uninucleate stage being most conductive to forming androgenic embryos (Peixe *et al.* 2004, Kim *et al.* 2004).

2. MATERIAL AND METHODS

Completely closed flower buds (4 and 5mm long) with uninucleate microspores used in the experiments were obtained from an *Aesculus hippocastanum, Aesculus carnea, Aesculus flava and Aesculus parviflora* trees, growing in the Botanical Garden "Jevremovac" and parks of the Belgrade. The selected buds was surface sterilized with 95 % ethanol and 70 % ethanol for about 5 min, followed by three rinses in sterile distilled water. Basal medium (BM) contained Murashige and Skoog (1962; MS) mineral salts, 2 % sucrose and was supplemented with the following [mg dm^{-3}]: panthotehenic acid 10.0, nicotinic acid 5.0, vitamin B_1 2.0, adenine sulphate 2.0, myo-inositol 100 and casein-hydrolysate 200 and 0.7 % agar. Medium contained BM with 2,4-D dichlorfenoxyacetic acid (2,4-D) and kinetin (Kin), 1.0 mg/L of each. Six or seven anthers were inoculated in each culture tube containing 8 cm^3 of the MSS induction medium. Embryo development and multiplication of androgenic embryos from suspension and anther culture proceed on medium with reduced contrentration of 2,4-D 0.01 mg/L and same concentration of kinetine. After medium for multiplication embryos were cultured on hormone free medium for embryo maturation. All media were sterilized by autoclaving at 0.9 x 10^5 KPa and 114 ^{0}C for 25 min. Anther cultures were grown under 23±2 ^{0}C temperature and a 16-h photoperiod with irradiance of 33 - 45 μmol m^{-2}s^{-1} produced by cool white fluorescent tubes.

Flow cytometry analysis: For preparing the nuclear suspension and staining with 4,6-diamino-2-phenylindole (DAPI) the method of Barany and Greilhuber (1995) was used. In brief, to release nuclei from the cells, cotyledonary embryos of approx. 10 mm size and leaves from nature as a control, were chooped with a razor blade in standard isolation buffer. The suspension of nuclei was filtred through a 50 μm nylon net in order to remove cell debris. Then filtrate was stored on ice. Shortly before measurement of the relative DNA-content, the suspension of nuclei was mixed with a 2.5 fold volume of staining solution which consisted 5 μg/cm DAPI. Measurements ploidy levels of androgenic embryos were performed after 6 months, while the second measurements were accomplished after 3 years. Each samples was measured twice.

3. RESULTS AND DISSCUSION

Androgenesis of mononuclear *Aesculus hippocastanum* micospores was induced in solid MS (Murashige and Skoog 1962) medium with some growth supstances (2,4-dichlorophenoxyacetic acid and kinetine, 1.0 mg dm^{-3} of each). Light and scanning microscopy confirmed that androgenic embryos of horse chestnut grown in suspension had formed by direct division microspores (Ćalić *et a*l. 2003/4). Embryos shown asynshronous development producing globular, heart, torpedo-like and green (Fig.1), himeric (Fig. 3) and albino (Fig. 5) embryos with different cotyledone numbers *in vitro* culture (Radojević 1995, Radojević *et al.* 1998, Ćalić *et al.* 2003/4). Transversal crossing of green (Fig. 2), himeric (Fig. 4) and albino (Fig. 6) embryo under fluorescent microscope shown that only green embryos consisted chlorophyll which fluorescent.

Flow cytometric analysis proved to be a quick and reproducible tool to asses polyploidy in *Aesculus spp*.

In the present study, initiated androgenic embryos and derived plantlets of *Aesculus spp*. were assessed for age-related chromosomal changes with flow cytometry analysis in screening periods during 3 years. A fifty % of analysed regenerants orginating from anther culture had haploid and 50 % had a diploid chromosome number, after 6 months in culture (Ćalić et al. 2003/4). Flow cytometric analysis of androgenic regenerants after 3 years in culture shown that persist haploids, diploids, tetraploids and octaploids (Fig. 7). As our investigation showed, polyploidy occured after 6months on medium without hormone.

In the case of chromosomal instabilities, polyploidy is the most commonly observed genetic change. The disposition for this effect may pre-exist in cell culture on the origin of somatic embryos. Prolonged time in culture (Tremblay *et al*. 1999) or any unfavorable condition or substance that affects or block plant metabolism, growth, or development (Zegzouti and Favre 1999) may also result in polyploidisation.

Polyploidisation as a result of endomitosis is belived to occur in the abscence of cell division, resulting in numerous copies within each cell and is showm in diverse plants (Joubès and Chevalies 2000).

Our result show that frequency of tetraploidy seems to be correlated with duration of *in vitro* culture. After induction of somatic embryogenesis the cycles of subculturing and repetative or secondary somatic embryogenesis can last over many years. We hypotheize that in these highly mitotic tissues that the prolonged stress of in vitro culture may have caused these tetraploid cells by restitution of mitosis and mitotic spindle failures.

Green (Fig.1.), himeric (Fig.3.) and albino (Fig.5.) androgenic embryo. Transversal crossing of green (Fig.2.), himeric (Fig.4) and albino (Fig.6.) embryo under fluorescent microscope.

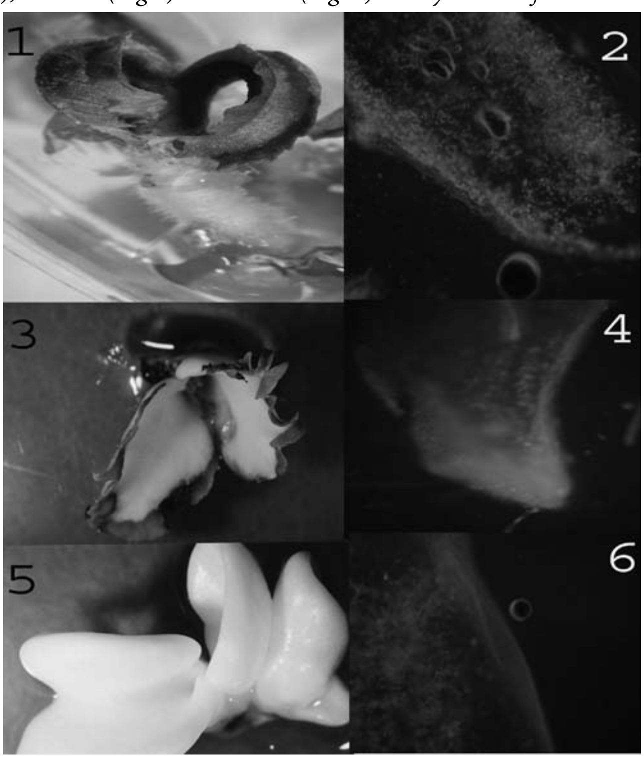
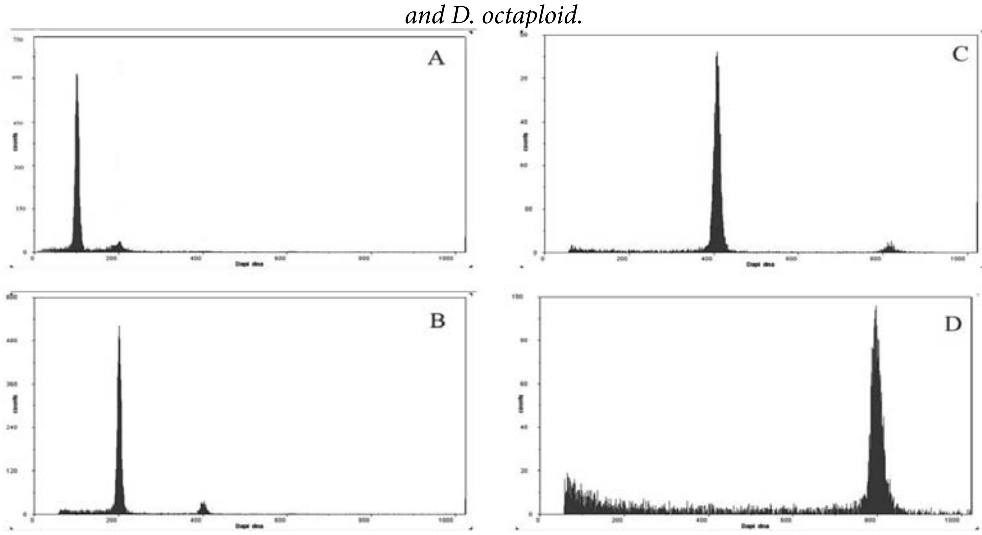


Fig. 7. DNA-histogram of DAPI-stained nuclei of Aesculus spp. A. haploid, B. diploid, C tetraploid and D. octaploid.



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SOMATIC EMBRYOGENESIS IN CONIFERS

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Abstract: *The forest industry is vital to the economics of many countries. Current reforestation practices require production of genetically superior trees possessing improved dimension increment, better wood quality, disease resistance and environmental tolerance. It takes an extremely long time to achieve these aims by conventional breeding. In vitro techniques, particularly somatic embryogenesis, offer possibility for mass propagation and synthetic seed production. Great success has been achieved in somatic embryogenesis in conifer species. Since first report of somatic embryogenesis from zygotic embryos of Picea abies in 1985, cultured explants of at least 30 different coniferous species have been induced to produce somatic embryos. The regeneration of Picea omorika, Pinus heldreichii and Pinus peuce via adventitious bud formation has been achieved. P. omorika has also been successfully regenerated by somatic embryogenesis while in P. heldreichii and P. peuce culture somatic embryogenesis induction was obtained.*

Key words: adventitious bud, conifers, plant regeneration, somatic embryogenesis, tissue culture

Somatic embryogenesis is the development of embryos from somatic, non-sexual, cells. This is accomplished through a series of developmental stages most of which are similar to zygotic embryogenesis. The process was first reported in *Daucus carota* (Steward et al. 1958). Since then somatic embryogenesis has been reported for many plant species and woody perennials which include both angiosperms and gymnosperms (Ruaud and Pâques, 1995).

Unlike flowering plants, regeneration through somatic embryogenesis in conifers is a more difficult process as many species are recalcitrant to *in vitro* conditions. The proper selection of culture medium, especially plant growth regulators, and control of the physical culture environment at each step of development are critical factors required for successful regeneration of embryos and subsequent growth into somatic seedlings.

In earliest studies, only embryonic tissue has initiated embryogenic cultures from conifers (Attree and Fowke, 1991). This included immature zygotic embryos dissected from seeds collected during the growing season, mature zygotic embryos dissected from stored seeds, and excised tissue from seedlings. In addition, megagametophytes of several conifer species have been cultured with varying success. The first report on initiation of embryogenic cultures in conifers was from immature zygotic embryos of *Picea abies* (Hakman et al. 1985), and was followed by induction of haploid embryos from larch megagametophytes shortly after (Nagmani and Bonga, 1985). Westcott (1992) described somatic embryogenesis induction from buds and needles of seven year old trees of *P. abies*. Recently, embryogenic tissue was shown to develop from vegetative shoot apices of mature trees of *Pinus patula* (Malabadi and van Staden, 2005).

For the induction of embryogenic tissue in *P. heldreichii* and *P. peuce* (Table 1), as in most other conifer species, the presence of both auxin and cytokinin in the medium is required. In *P.*

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omorika shoot explant culture the embryogenic cultures were induced only with benzyladenine (Budimir and Vujičić, 1992). Cytokinin as a sole growth regulator has previously been reported to induce the formation of embryogenic tissue in *Abies alba* (Schuller et al. 1989) and in *A. nordmanniana* (Norgard and Krogstrup, 1991). However, in mature zygotic embryo culture of *P. omorika* high frequency of somatic embryogenesis induction was obtained in the presence of auxin and cytokinin (Kolevska-Pletikapić et al., 1995).

Table 1. Somatic embryogenesis induction and maturation

Species	Explant	Basal medium	Induction growth regulators	Maturation growth regulators
P. omorika	Shoot explant	LP	BA 9-45 µM	ABA 12 µM
P. heldreichii	Megagametophyte	GD	2,4-D 9 µM + BA 2.2 µM	
P. peuce	Megagametophyte	GD	2,4-D 9 µM + BA 2.2 µM AB	A 10 µM

LP-von Arnold and Eriksson (1981) medium; GD-Gresshoff and Doy (1972) medium, as modified by Sommer et al. (1975); ABA- abscisic acid; BA-benzyladenine; 2,4-D-dichlorophenoxyacetic acid.

Most embryogenic cultures induced from species within the Pinaceae are similar in appearance. Embryogenic cultures are generally translucent to white with glistening appearance due to a mucilaginous matrix produced by the cells (Fig. 1). Cultures consist primarily of numerous somatic embryos protruding from mucilaginous tissue (Fig. 2). Somatic embryos are polarized structures consisting of an embryogenic dome subtended by elongated suspensor (Fig. 3).

Fig. 1. Embryogenic tissue in P. peuce megagametophyte culture

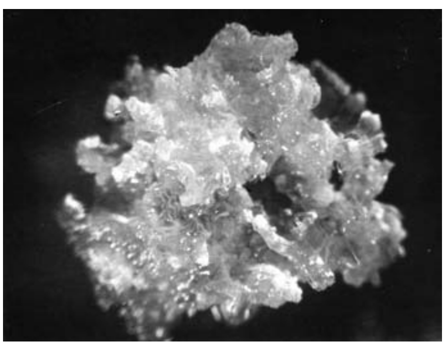
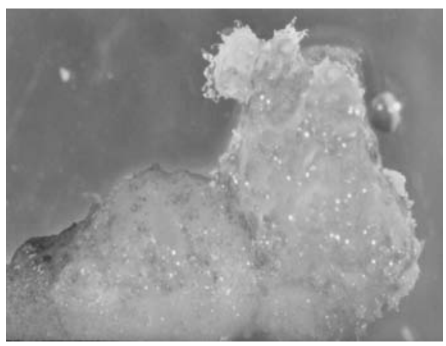


Fig. 2. Somatic embryos of P. omorika protruding from embryogenic tissue



The medium containing auxin and cytokinin has been shown to be essential for the proliferation and maintenance of embryogenic cultures in most of the reported conifers. In *Picea omorika* continuous formation of new embryos was obtained in the presence of 9 µM 2,4-D and 4.5 µM BA. In *P. peuce* and *P. heldreichii*, proliferation was obtained on the medium containing reduced concentration of growth regulators when compared to induction medium. On the maintenance medium embryogenic cultures of *P. omorika* and *P. peuce* consisted of numerous somatic embryos at different developmental stages, continuously multiplying by mechanism similar to cleavage polyembryogenesis (Fig. 4). Cleavage polyembryogenesis is the process where embryo dome cleaves to form several genetically identical embryos (Vujičić and Budimir, 1995). New embryos could also arise through cell division of suspensor cells. Long term maintenance of proliferating tissue requires regular subculturing on a fresh solid medium in two to four week intervals.

Fig. 3. Immature somatic embryo of P. omorika

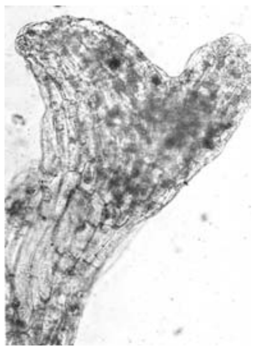


Fig. 4. Cleavage polyembryogenesis in P. omorika culture

While maintained on a medium containing both auxin and cytokinin, somatic embryos continue to proliferate but do not mature. In early studies, maturation of conifer embryos was attempted by culturing immature embryos on medium containing reduced or no plant growth regulators, but maturation was infrequent. Later reports using ABA generally suggested its beneficial effect on embryo maturation (Attree and Fowke, 1993). It has been hypothesized that ABA inhibits cleavage polyembryony, thus allowing further embryo development. Maturation of *P. omorika* and *P. peuce* was obtained in the presence of ABA (Table 1). However in *P. peuce* only first stages of embryo maturation were accomplished (Fig. 5). In *P. omorika*, upon transfer onto the maturation medium, the embryos increased in size, attaining more globular shape. Upon further development embryos elongated and ring of cotyledons emerged from the peripheral zone of the apical dome (Figs. 6 and 7). On the medium without growth regulators successful germination of *P. omorika* somatic embryos was achieved. The regenerated plantlets were transfered to soil (Budimir and Vujičić, 1992).

Fig. 5. Somatic embryo maturation in P. peuce.

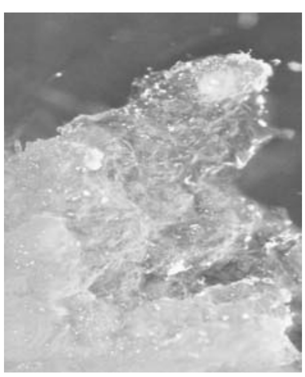
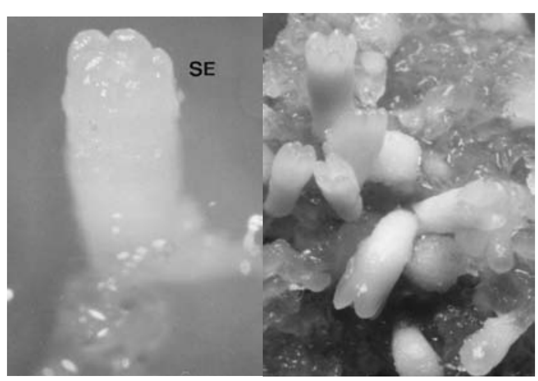


Fig. 6 and 7. Cotyledonary embryos of P. omorika



The successful plant regeneration of *P. omorika* (Budimir and Vujičić, 1992; Budimir, 2003/4) and *P. heldreichii* (Stojičić et al. 1999; Stojičić and Budimir, 2004) and establishment of regeneration system by somatic embryogenesis in *P. peuce*, offer the possibility for plant propagation of these endemic species under *in vitro* conditions. However, in these endemic species as well as in most conifer species, further optimization of culture conditions for each step of embryo development is needed in order to obtain large-scale production of good quality embryos showing high vigour and with potential for successful acclimatization. A more complete understanding of the biological and molecular processes involved in both somatic and zygotic embryogenesis will be required for cost effective production of somatic embryos for reforestation purposes.

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IN VITRO PROPAGATION OF ENDANGERED RELIC PLANT SPECIES *MALOSORBUS FLORENTINA*

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Abstract: *Malosorbus florentina (Zuccagni) Browicz is a relic plant species distributed in Apennines, Balkans and in Asia Minor. In Serbia this species has been protected by law as a natural rarity.*

An extremely small population of this species with only several trees was found on Mt. Sokolovica in central part of Serbia. Fruits with seeds were collected from these plants in 2003.

In order to save this endangered species we try to develop a protocol for in vitro propagation as one of the ex situ conservation method.

In vitro culture was successfully established from seeds after stratification (4 months at +4°C). The best multiplication rate of shoots was obtained on MS medium supplemented with BAP, IBA and GA_3, all in concentration of 1µM. Shoots did not spontaneously form roots in vitro on hormone-free half-strength MS medium. Experiments in order to find optimal conditions for rooting are in progress.

Keywords: *Malosorbus florentina, in vitro* propagation

1. INTRODUCTION

Malosorbus florentina (*Maloideaea, Rosaceae*) was described for the first time by Zuccagni (1809) under the name *Crategus florentina*. After years of investigations, Browicz (1983) considered the taxon "x *Malosorbus florentina*" as an intergeneric hybrid, resulted from a cross of *Malus sylvestris* and *Sorbus torminalis*. Today this species is distributed in the Apennines, Balkans and a few localites were described in Asia Minor. The distribution area is mainly restricted to some refugial habitats.

The first data of the existence of *M. florentina* in Serbia originate from the end of 19th century (Bornmüller, 1888). At this moment very small and vulnerable populations are present at only nine localities in Serbia. The northernmost point of distribution in Serbia and Balkan was found during the floristic investigation of Mt. Sokolovica, near the town of Niš. This population includes only one mature fertile tree and about twenty juvenile specimens in vicinity of the oldest one (Tomovic et al. 2003).

Malosorbus florentina is included in the global 1997 IUCN Red List of Threatened Plants under the rare (R) category (Walter and Gillett, 1998) and in the European Red List of Globally Threatened Animals and Plants (1991) in the same category. In Serbia it has been protected by law as a natural rarity (gazette under N° 66/91, 83/92, 50/93).

Although this species is under protection by the law, this is not enough for the conservation and protection. In order to save this endangered species we tried to develop protocol for *in vitro*

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propagation as one of the *ex situ* conservation method. Efforts should be made to reintroduce *M. florentina* to its natural habitats (Mišić et al., 2005).

2. MATERIAL AND METHODS

Plant material

Fruits of *M. florentina* were collected from Mt. Sokolovica (village Rudare, locality Veliki Do) in summer 2003. Seeds from that fruits were surface sterilized with 0.2% NaOCl for 10 minutes and thoroughly washed three times with sterilized distilled water.

Establishment of *in vitro* culture

After four months of stratification at 4°C seeds were aseptically transferred on hormone-free half-strength MS (Murashige and Skoog, 1962) medium, supplemented with 7g l^{-1} agar, 30 g l^{-1} sucrose and 100 mg l^{-1} myo-inositol.

The seedlings obtained from the seeds (Fig. 1a) were transferred on fresh medium for multiplication after 5 weeks. Multiplication medium contained MS salts and vitamins supplemented with 6-benzylamino purine (BAP), indol-3-butyric acid (IBA) and giberellic acid (GA_3) all in concentrations of 1 μM.

Fig. 1: In vitro culture of Malosorbus florentina (a) seedling, (b) glass vessels with proliferated shoots and (c) shoot

The various concentrations of BAP (0, 0.5, 1, 2, 5 and 10 μM) were used to study its effect on shoot proliferation. For this purpose, stem segments were inoculated on medium. Experiments lasted for 5 weeks. The concentrations of IBA and GA_3 were the same as in the multiplication medium.

The pH of all media was adjusted to 5.8 prior to autoclaving at 114°C for 25 min. All cultures were grown in glass vessels, which contained 100 ml medium (Fig. 1b). Cultures were kept in a growth chamber room at 25 ± 2°C, under long day conditions (16h light / 8h dark cycle). Light was provided by "Tesla" Pančevo white fluorescent tubes (photon flux density 50 μmol m^{-2} s^{-1}).

Initiation of roots

Rooting of the shoots from *in vitro* culture was difficult like in many woody plants. We were trying to induce roots initiation and elongation in a few different ways:

- putting shoots on MS multiplication medium supplemented with different concentrations of IBA (2, 4, 6, 8 and 10 μM);

- changing sources of Fe in MS solution ($FeCl_3$ instead of FeEDTA in concentrations of 0, 0.1 and 0.2 mM);

- providing better aeration of medium using vermiculite with MS salts and vitamins and IBA in concentrations of 2, 4 and 8 μM, without agar and

- attempting to transform *M. florentina* using *Agrobacterium rhizogenes* strain A4M70GUS. The explants were inoculated with hypodermal needle which was dipped in bacterial suspension.

3. RESULTS

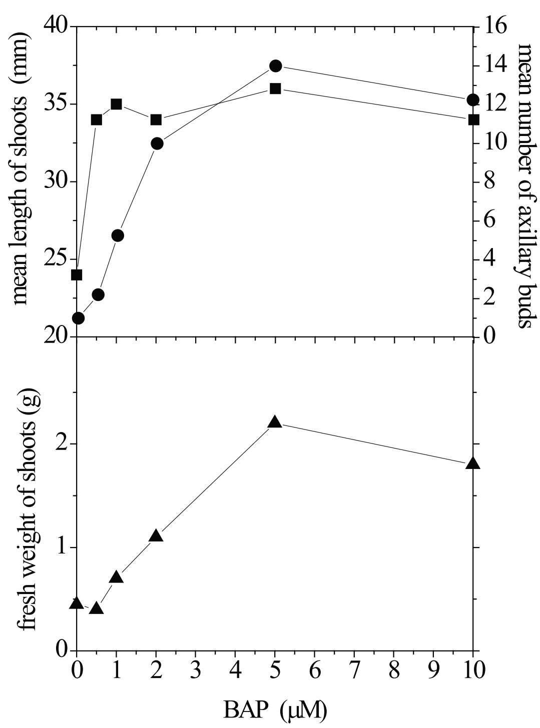
The satisfactory multiplication rate of shoots was obtained on MS medium supplemented with BAP, IBA and GA_3 all in concentrations of 1 μM. Shoots from that medium looked healthy and strong (Fig. 1c) and they were transferred to the fresh medium every 5 weeks. These shoots were used in other experiments.

In order to increase the multiplication rate, the basal medium was supplemented with BAP in concentrations of 0, 0.5, 1, 2, 5 and 10 μM. As has been reported for many other plant species, media supplemented with different BAP concentrations were efficient in initiation and proliferation of axillary buds in *M. florentina* (Fig.2). Although the higher concentrations of BAP (2, 5 and 10 μM) enhanced axillary buds induction (Fig. 2), shoots from these media were with small leaves, lightgreen and hyperhydrated.

The induction of roots on shoots obtained from *in vitro* cultures is crucial point of micropropagation process. The shoots of *M. florentina* from multiplication medium did not spontaneously form roots *in vitro*.

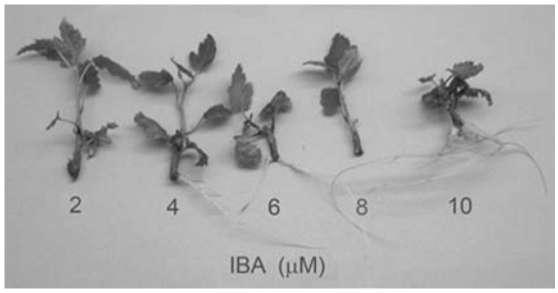
The application of auxins to improve the percent of rooting is commonly used treatment for many plant species. The most widely used auxin for stimulation of the rooting process under *in vitro* conditions is IBA.

Fig. 2: The effect of BAP concentrations on mean length of shoots (-▪-), mean number of axillary buds (-•-) and fresh weight of shoots (-▴-)



There was no t clear differences in r ooting r esponse b etween IB A-treated a nd un treated explants of *M. florentina*. Namely, the presence of IBA in media in co ncentrations of 2, 4, 6 a nd 8 μM did not significantly increase the roots formation. Only a few not very vigorous roots have been formed (Fig. 3), but when rooted shoots were transferred from agarous medium to greenhouse, all of them died after a week.

Fig. 3: The effect of IBA on in vitro rooting of Malosorbus florentina

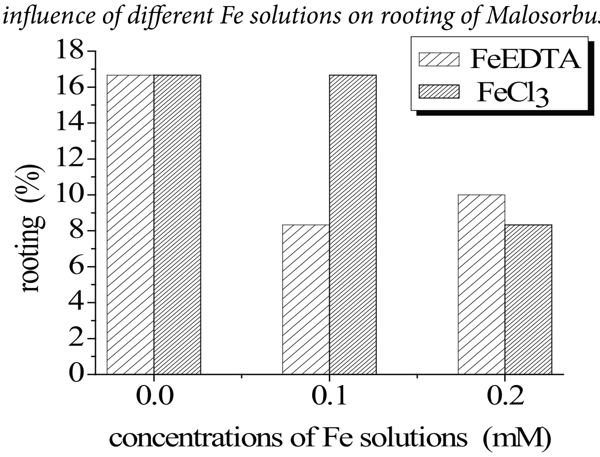


It is w ell known that the ability of plant tissue t o form adventitious roots depends on interaction of ma ny ex ogenous a nd endogenous fac tors. One o f them is ir on, which is ess ential micronutrient in volved in fundamental p rocesses suc h as c hlorophyll an d D NA s ynthesis a nd hormone formation (Molassiotis et al., 2003/4). I n MS medi um commonly used in plant tissue culture iron is presented in chelated form of Fe-EDTA. In our experiment we compared the effect of organic Fe-EDTA with inorganic $FeCl_3$ on initiation of roots.

The p ercentage of r ooted sho ots was t he highest on medium without Fe a nd on medium with F eCl_3 (18.63%) in co ncentration o f 0.1 mM in co mparison t o co mmonly us ed F eEDTA (8%). On me dium s upplemented wi th 0.2 mM F eCl_3 nu mber of ro oted shoots decreased (Fig. 4). It s eems t hat *M. florentina* is t olerant t o Fe deficiency, b ut n umber o f r ooted s hoots i s still unsatisfactory.

According to Newell et a l. (2003) the low oxygen concentration in t he solid agar medium can be the main problem in roots induction and elongation processes. Freshly prepared solid agar medium will have a dissolved oxygen concentration close to 0% (Gorge and Sherrington, 1993). The final concentration after a few-week-last experiment is still less than 3% oxygen, much lower than atmospheric oxygen at 21%. Substrates other than agar, such as vermiculite, can overcome this problem.

Fig. 4: The influence of different Fe solutions on rooting of Malosorbus florentina



However, in our experiments, there was not a clear relationship between improved rooting in aerated vermiculite compared to solid agar medium. In all cases callus-like tissue was formed at the end of shoots. Only one of 25 shoots has got several short roots developed from callus. That rooted shoot did not survive after transfer to the greenhouse.

We also tried to induce formation of "hairy roots" of *Malosorbus florentina*. It is well known that Ri plasmid of *Agrobacterium rhizogenes* comprises several genes which could modulate the responses of transformed tissues on auxins, or even have effects like auxins (Zambrysky et al., 1989). For this experiment forty explants of *M. florentina* were inoculated with *A. rhizogenes* strain A4M70GUS. Transformation of shoots was unsuccessful. Namely, there was no induction of "hairy roots". i.e. efficiency of inoculation was 0%.

Several other experiments in order to find optimal conditions for rooting of *Malosorbus florentina* are still in progress.

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THE CONTRIBUTION OF JOSIF PANČIĆ TO PROTECTION OF BIODIVERSITY AND TO GENOFOND'S PRESERVATION OF SERBIAN FLORA

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Abstract: *Josif Pančić gave an extremely great contribution to research of Serbian flora and also endemic plants. He described about 200 taxons (Mayer, Diklić, 1967.), from which 49 represents undisputably plant species. During the further and modern botanical investigations, all the residual taxons have been classified to categories lower than species (varietets, forms). In spite of that, the number of 49 species is great and shows how much Pančić contributed to knowledge about Serbian flora, as well as to Balcanian peninsula's flora. Many of these species are endemic: Picea omorica, Ramondia serbica, Geum bulgaricum, Potentilla visianii, Coronilla elegans, Stachys anisochila. His revelations contributed to a closer study and protection of endemic plants, which takes central place in biodiversity of Serbian flora. Considering the time and conditions of his research, his work gets true dimension, unreachable in many ways at present time.*

Key words: Josif Pančić, endemic plants, biodiversity, Serbia

1. INTRODUCTION

The Serbian flora is unic by its various and numerous plant species. Almost half of 6 600 plant species of Balcanian penninsula are in Serbia (3 155). Among them, there are 217 endemic and relict plants that give a specific character to our vegetation. Different from the most area of Europe which had been under ice for millions of years, the area of Serbia belongs to the parts of Balcanian penninsula that have had well protected refugial habitats. In these habitats, the tertiar plants had survived ice age. In this way, the geological and historical factors had limited the expansion of many species to the southern parts of Balcanian penninsula. Serbia is a habitat for many tertiar species and also for plants of later time periods as a result of these specific ecological circumstances in geological past. These plants are endemic and relict species that represents the rear remains of an ancient flora. The relict plants can be closer determened by the time of their formation as tertiar, glacial, postglacial and other relicts.

2. MATERIALS AND METHODS

The character of this paper is predominantly sythetic. Among the works that have been used, the most important were "Flora kneževine Srbije ili vaskularne biljke koje u Srbiji divlje rastu" (J. Pančić, 1874.); "Flora jugoistočne Srbije" (Adamović, 1908.) and "Flora Srbije I-IX" (The group of the authors, 1973.).

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3. DISCUSSION

The large number of plant species described by Josif Pancic represents relict and endemic species of the Balcanian peninsula. The discovery of this species had contributed to more complex and complete study of history, horology and florogenetyc relations of Serbian flora. Some of this species represents the remains of the tertiar flora that had been destroyed during the ice age.

Picea omorica is one of this remains and it is paleoendemyte and stenoendemyte of the western Serbia. This plant also exists in the eastern Bosnia in the middle part of river Drina and in the canyon of Milesevka river (Matovic, 1982.). Recently have been described an infraspecial taxon of this species Picea omorica var. vukomanii (Pavlovic et Matovic) which have a small habitat in the canyon of Milesevka river. The closest related species of Picea omorica (except those in the middle part of river Drina) exist on the Himalayi Mountains and on the Rocky mountains in North America. According to this, Picea omorica have had much greater areal in the earlier geological periods.

Very significant Pancic's discovery is Ramondias, two species that belongs to the tropical and subtropical family Gesneriaceae which have very small number of temperate area representative species. Franch botanist Risar discovered the first Ramondia species (1805.). He had described this plant as Ramondia pireneica, in memory of the franch botanist Ramond that had been researching the Pirineic peninsula flora during the eighteenth century.

Almost seventy years later, Pancic had discovered new species of Ramondia on the Rtanj Mountain in eastern Serbia. He named her Ramondia serbica (1874.). Eight years later, the court-doctor and passionate explorer of sorrounding flora of Nis, dr Sava Petrovic had discovered a new species on Suva Mountain and in Jelasnicka klisura.

He had sent the plant for inspection to Josif Pancic. After the examination, together they had described the plant as Ramondia nataliea in honor of the Serbian queen Natalija.

During the tertiary, the plants of arcto-tertiary flora had had a much larger areal. With the beginning of the ice age, these thermophilic plants had retired to the southern refugial habitats. One of these refugiums is Serbia, especially it's southern regions which are one of the most important habitats of the tertiary termophilic flora on the Europian continent. Many of this tertiary flora species had dissapeared as a result of their impossibility of adaptation to the change of the climate conditions. The preserved species that had survived the ice age in the refugiums of the Serbia represent the remains of an ancient flora and can be considered as live fossils. Serbia is a habitat for all categories of the endemytes- from paleoendemyte, stenoendemyte, local endemyte, subendemyte to neoendemyte species. We can only mention some of this important endemytes: Ramondia serbica Panč. (Rugovska klisura); Geum bulgaricum Panč. (Prokletije); Potentilla visianii Panč. (Koprivnik on Kosovo); Coronilla elegans Panč. (Dečanska mountain, Dečanska bistrica river), Stachys anisochila Vis. et Panč. (Žljeb on Kosovo); Reichardia macrophylla Vis. et Panč. (sorrounding area of Peć); Goniolimon serbicum Vis. et Panč. (sorrounding area of Priština); Euphorbia subastata Vis. et Panč. (sorrounding area of Peć); Wulffenia blecicii Lakušić (Prokletije mountains); Dinathus microlepis Boiss.(Prokletije mountains); Alyssum scardicum Wettst. (Prokletije mountains); Sempervivum kosaninii Praegr. (Prokletije mountains); Geum reptans (Šar mountain); Potentilla speciosa walld. (Prokletije mountains); Pedicularis brachyodonta Schloss. et Vukot. (Kosovo); Ranunculus scutatus Waldst et Kit. (Koprivinik, Prokletije mountains); Alyssum markgrafii O. E. Sculz (sorrounding area of Kosovska Mitrovica); Minartia bosniaca G. Back, K. Maly (Koprivnik and Ločanske mountains on Kosovo); Daphne blagayanna Freyer (Kosovo); Centaurea kosaninii Hayek (Šar mountain); Forsythia europea Deg et Bald. (sorrounding area of Peć and Đakovica); Pancicia serbica Vis. (Prokletije and Šar mountain); Edrainthus montenegrinus Hork et Lakušić (Prokletije mountain); Cucurbita pancici Vis. (

Nedžinat on Kosovo); Crepis dinarica G. b eck (Žljeb, Lumbardske mountains, Nedžinad and Ločanske mountains on Kosovo); Iris reichenbachii Heuff. (Peklen near Peć); Fumana bonaparti Maire et Petitmenigen (sorrounding area of Peć); Gentianella crispata (Vis.) Holub. (Bogićevica, Greben and Maja Potkas on Kosovo); Cerastium grandiflorum Waldst. et Kit. (Žljeb on Kosovo); Valeriana pancicii Hal. et Bad. (Maja Rosulija, Maja Nedžinat, Jelenak, Marjaš and Pasji vrh on Kosovo); Crocus scardicus Košanin (Šar mountain); Crocus kosaninii Pulević (Kačanik, sorrounding area of Vučitrn, Brezovica, Štimlje and Lipovica on Kosovo).

From this reasons, Serbia can be considered as one of the central regions of floristic diversity on the Balcan.

4. CONCLUSION

The endemic plants points out the specifity of Serbian flora and it's relations to the distant parts of the world. For example, stenoendemyte Picea omorica have close relatide species only in eastern Asia and North America. Wulfenia carinthiaca is the endemite of Prokletije Mountain and the Alps. The closest related species of this plant can be found in Siria, Afganistan, northern India, eastern Asia and in North America. Forsytia europea which exist in the mountain area of Metohija have close related species only in Asia. The both species of Ramondia (R. nathaliae and R. serbica) have one close related species on Pirineic peninsula, and others are in China.

Ramondia serbica represent the rarity among the plants and it can be considered as a particular phenomenon of the Serbian and also Europian flora. The poikilohydricity and anabiosis are the properties of the lower plants (phylogeneticaly older forms of the plant world). R. serbica has this properties which point us the age of this plant. Considering the extraordinary floristic, fitogeografic and botanical significance of Ramondia serbica, the Pancic's discovery of this species represents his the most important contribution to Serbian and Balcanian flora.

The endemites of Serbia have a disjunct distribution and exist on the limestone, dolomite and serpentine substrate. They can also be found in the gaps of the rocks and on eroded substrate.The endemites deserve an extremely attention as an unrepeatable part of Serbian and the World's fond of genes. They give the specific character to Serbian flora which has a large number of endemyc communities and higher vegetation units as a result of very variable climatic, petrographic, edaphic and orographic conditions. The richness and diversity of the Serbian flora plants points out the continuity of the favourable environmental conditions in this area. They are very important object for scientific research and also a significant historical document about the vegetation of Serbia.

The human population have endangered many endemyc species. Urgent measures should be taken for the protection and reintroduction of endemyc plants to their natural habitats. This problem has a national interest and it can be solved by permanent work on the education of the students and adults, which is one of this paper's purpouses.

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THE RESOURCE POTENTIAL OF MEDICINAL FLORA OF MT. KOSMAJ

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Abstract: *Diversity of native MAP species and populations, utilization of their exploitation for various human activities, genetic resourse etc. is the matter of investigations in different plant communities and sites in Serbia.*

Our investigations were carried out in the forest and meadow communities on Kosmaj Mt. (near Belgrade), on limestone and serpentine parent rock. Beech (Fagetum submonatnum) and oak (Quercetum frainetto-cerris) are dominant forest communities. They are mainly in different stages of degradation with Festucetum vallesiacae as a major type of meadow community.

Total of about 557 plant species are coenobionts of these communities, and among them 32% are medicinal plants. In relation to abundance, sociality and presence degree, it is possible to select: Geranium robertianum, Rubus caesius, Aspidium filix-mas, Crataegus monogyna, Origanum vulgare, Potentilla recta etc.

Key words: MAPs, Kosmaj, serpentine

1. INTRODUCTION

Medicinal and aromatic plant species present significant natural potential of forest and meadow ecosystems in Serbia. These species have wide use in folk and official medicine, and because of that the exploitation of medicinal and aromatic plants are very intensive.

As the exploitation should not endanger population of medicinal plants, it is very important pay attention to several factors. Some of them are: abundance, sociality and presence degree in different communities, soil characteristics etc.

In this paper, investigations of diversity of MAP species and possibility of their exploitation were carried out on Kosmaj. Kosmaj is a mountain, situated in central part of Serbia, near Belgrade. The Institute for Nature Conservation of Serbia putted Kosmaj under protection as landscape of remarkable distinguishes. On investigated area, the forest communities are dominant and the meadows have secondary character.

2. MATERIAL AND METHODS

Floristic investigations have been comprehended common and special research of flora. By common research the whole flora of Kosmaj Mt. is comprehended, and by special research specific ecological characteristics of medicinal and aromatic plants.

Analysis of medicinal and aromatic plants has been performed according to Sarić (1989). Determination of plant material has been done by standard floristic methods. The phytocoenological investigations were performed by the composite scale of abundance and the degree of coverage after Wasthoff-Van Der Maarel (1973), ranging from 1 to 9. The life forms were determined

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according to a method of Raunkiaer (1934) and Kojić et al. (1997). The phytogeographic analysis was done according to a method of Gajić (1984).

3. RESULTS

Diversity of native MAP species and populations, utilization of their exploitation for various human activities, genetic resource etc. is the matter of investigations in different plant communities and sites in Serbia.

Our investigations of medicinal plants were carried out in the forest and meadow communities on Kosmaj, on limestone and serpentine parent rock. On the investigated areas by soil study, two soil types are identified: the leached brown soil on sandstone (luvisol) and rendzina on flysch sediments. Both soil types are characterized by relatively unfavourable contents of macroelements (Kadović et al., 2003). The comparative analysis of the soil and ecological indices for plants shows their correlation (Obratov-Petković, et al., 2004).

The wider area of Kosmaj Mt. is distinguished small diversity of plant communities. The forest communities occupy the largest area of Kosmaj Mt.. Beech (Fagetum submonatnum) and oak (Quercetum frainetto-cerris) forests are dominant forest communities. They are mainly in different stages of degradation with Festucetum vallesiacae as a major type of meadow community. Besides this meadow community, ass. Chrysopogonetum grylli is wide spread, also. By their characteristics, these meadow communities indicate on prairie character of investigated site.

On investigated area in different forest and meadow communities, there are about 557 taxa. Among them medicinal and aromatic plant species present significant natural potential, considering their high presence degree in these plant communities. According to our researches, from total number of plant species 32% species are medicinal plants. Generally, family *Asteraceae* is the richest by taxa (63), than follow fam. *Fabaceae* (56), *Poaceae* (49), *Lamiaceae* (37), *Rosaceae* (28), *Scrophulariaceae* (28) and *Brassicaceae* (25). Except family *Poaceae*, all these families are the richest by medicinal species, simultaneously. Within family *Poaceae* only one species is medicinal. The largest number of medicinal plants is noticed in the families *Lamiaceae* (19), *Asteraceae* (18), *Rosaceae* (16), *Scrophulariaceae* (11) and *Fabaceae* (11). The most of these species have wide use in folk and official medicine and because of that they are exploited significantly. For sustainable use of medicinal plants it should be pay attention to their abundance, sociality and presence degree in different plant communities, but also to a way of plants collection.

The table 1 shows some medicinal plants with their abundance, floral elements and life forms. Number of medicinal plants in flora of Kosmaj Mt. is significant, but we had to pay attention to their abundance in different plant communities in order to recommend appropriate species for exploitation. According to our researches we could select medicinal plants with high values of abundance and recomme them for exploitation. These species are shown in the table 1.

Phytogeographic analysis of flora of Kosmaj Mt. indicates domination of sub-Mediterranean and Eurasians floral elements (Obratov-Petković, et al., 2004), and from the table 1 we can see that among medicinal plants Eurasians floral elements are dominant (18).

According to Obratov-Petković, et al. (2004) by life forms analysis it is established domination of hemicriptophytes in flora of Kosmaj Mt. Also, among medicinal species hemicriptophytes are dominant group (24).

Distribution of medicinal plants is very non-uniform, what is generated by degradation of forest and meadow ecosystems and different types of geological layer (limestone and serpentine). The number of medicinal plants is the highest on meadow communities. In the case of forests, beech forest Fagetum submonatnum is richer by medicinal plants, than oak forest Quercetum frainetto-cerris.

Table 1. The medicinal species which are presented with high values of abundance in different plant communities

Species	Abundance	Floral element	Life form
Fagus sylvatica	8	Se.	p
Quercus cerris	8	Is. subm	p
Rubus caesius	8	Se.	np
Galium verum	7	Evr.	g
Origanum vulgare	7	Evr.	g
Campanula glomerata	5	Evr.	h
Centaurium umbellatum	5	Subse.	h
Geranium robertianum	5	Subcirk.	th
Crataegus monogyna	5	Subse.	p
Teucrium chamaedrys	5	Subpont.-subm.	dc
Centaurea jacea	5	Subevr.	h
Hieracium pilosella	5	Subse.	h
Tussilago farfara	5	Subevr.	g
Fragaria vesca	5	Evr.	h
Achillea millefolium	3	Evr.	h
Medicago falcata	3	Subpont.-ca.	h
Hypericum perforatum	3	Subevr.	h
Stachys recta	3	Subpont.	h
Clematis vitalba	3	Cirk.	h
Agrimonia eupatoria	3	Evr.	h
Potentilla recta	3	Subpont.-ca.	h
Prunella vulgaris	3	Subevr.	h
Cichorium intybus	3	Subevr.	h
Mentha arvensis	3	Cirk.	g
Artemisia vulgaris	3	Cirk.	h
Aspidium filix-mas	3	Kosm.	h
Bellis perennis	3	Subse.	h
Matricaria chamomilla	3	Evr.	t
Taraxacum officinale	3	Evr.	h
Capsella bursa-pastoris	3	Kosm.	th
Glechoma hederacea	3	Evr.	h
Chelidonium majus	3	Evr.	h
Plantago major	3	Evr.	h
Rumex acetosa	3	Evr.	h
Rosa canina	3	Subse.	np
Sanguisorba minor	3	Subevr.	h
Veronica chamaedrys	3	Subse.	g
Symphytum officinale	3	Subse.	h

Comparing plant communities developed on serpentine and limestone we can see that communities at limestone distinguish bigger floristic diversity (Harrison, 1999; Lombini et al., 1999). This fact is confirmed on localities which we investigated. Thereby, plant communities developed at limestone are richer by medicinal species than the other developed on serpentine.

A very important parameter for the utilisation of medicinal plants is the quality of active substances that medicinal plants content. The quality of the plant active substances depends on its physiological potential and condition, but also on the environmental factors. Chemical characteristics of soil are among the most important environmental factors. Some of investigated plant communities are situated on serpentine soils. As the soils developed at serpentine have high concentration of heavy metals, some plants can accumulate these metals. High concentration of heavy metals influence unfavourably on quality of the plant active substances.

In relation to abundance, sociality and presence degree, it is possible to isolate species that could be recommended for collection: *Fagus sylvatica, Qercus cerris, Geranium robertianum, Rubus caesius, Aspidium filix-mas, Crataegus monogyna, Origanum vulgare, Potentilla recta, Teucrium chamaedrys, Hypericum perforatum, Galium verum*, *Centaurium umbellatum*, *Achillea millefolium, Mentha arvensis, Cichorium intybus*, etc.

4. CONCLUSION

On Komaj Mt. the forest communities occupy the largest area. Beech (*Fagetum submonatnum*) and oak (*Quercetum frainetto-cerris*) are dominant forest communities. They are mainly in different stages of degradation with *Festucetum vallesiacae* as a major type of meadow community. In these communities medicinal and aromatic plant species present significant natural potential.

About 557 taxa consist of flora of investigated area. Among them 32% species are medicinal plants.

The meadow communities are the richest by medicinal species. In the case of forests, beech forests are richer by medicinal plants, than the oak forests.

The plant communities are developed on serpentine and limestone. Those that are developed on limestone are floristic richer, and thereby richer by medicinal species than those developed on serpentine. Considering our researches we can recommend to avoid collection medicinal plant from serpentine (because high concentration of heavy metals which some medicinal species can accumulate). Also, on the bases of abundance, sociability and presence degree of medicinal plants, for collecting we could recommend following species: *Fagus sylvatica, Qercus cerris, Geranium robertianum, Rubus caesius, Aspidium filix-mas, Crataegus monogyna, Origanum vulgare, Potentilla recta, Teucrium chamaedrys, Hypericum perforatum, Galium verum*, *Centaurium umbellatum*, *Achillea millefolium, Mentha arvensis, Cichorium intybus*, etc.

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FINNISH FORESTRY AS A THREAT FOR THE EXISTENCE OF SPRINGS AND SPRING FENS IN KUHMO, EASTERN FINLAND

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Abstract: *Springs and spring fens are specific habitats, characterized by cool and stable conditions due to the flow of groundwater. They have a rich flora of vascular plants and mosses, and can be regarded as key habitats for biodiversity. Forestry and groundwater uptake have destroyed most of the springs in southern Finland. In Kuhmo, central eastern Finland there are still numerous springs in natural conditions. Despite the new forestry legislation springs are still vulnerable, and adding to awareness is needed among foresters and forest owners.*

Key words: groundwater, forestry drainage, Eastern Finland, small watercourses, plant diversity

1. INTRODUCTION

Springs are places where groundwater comes to the surface of the earth. According to hydrological characteristics springs can be divided into two main groups, eustatic and astatic springs. In eustatic springs the discharge of groundwater is stable in all seasons and from year to year. The water temperature is approximately the same as the mean annual air temperature, for example in southern Finland about +4°C. Usually the flow of groundwater is rather abundant in eustatic springs, up to 10 000 m^3/day. Eustatic springs typically form a small pond, and the water comes up in the bottom of the pond. Often the water forms a stream from the pond.

In astatic springs both the discharge of water and its temperature vary according to seasons. Typically the groundwater flow is highest after the snow melt period, but in the warmest and driest periods of summer as well as in the winter astatic springs often dry up completely.

On the basis of the water quality springs are divided into three groups, calcareous springs with pH above 7 and specific conductivity above 20 mS/m, intermediate springs with pH between 6 and 7 and specific conductivity between 5 and 20 mS/m, and poor springs with pH below 6 and specific conductivity below 5 mS/m.

Due to continuous moisture spring fens often occur around springs. Spring fens are mires, in which characteristic species of springs and fens form a mixture. The proportion of spring species is about half of the coverage. Mires are peat-forming waterlogged ecosystems with plant species tolerating continuous moisture and anoxic conditions around their roots. In the boreal coniferous zone mires can cover more than 50 % of the flat terrain landscapes. Small rich fens have been fairly common along the Salpausselkä marginal formations due to the frequent springs below the slopes. There have also been small local spring areas in other regions with glaciofluvial formations (Heikkilä, H. 1992).

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The term "spring" in ecological sense should only be used for areas where the hydrostatic potential and movement of water usually exceed evapotranspiration, giving rise to the water table. Consequently the term "fen" should be only used for waterlogged areas where the groundwater does not give rise to the water table (Warncke 1980)

In the Finnish mire site type classification system spring vegetation and seepage surfaces are considered as specific mire types (Eurola & Holappa 1985, Eurola et al. 1994).

2. TYPICAL AND INDICATOR SPECIES OF SPRINGS

In springs there is a rich flora of vascular plants and mosses. Due to the cool groundwater the temperature in the summer time is lower than in surrounding habitats. Therefore many northern species have their southernmost occurrences in springs. On the other hand, springs do not freeze in the winter, and therefore many southern species are present in springs as well (Moen 1994). A number of species are restricted in springs, and they do not usually grow in other kinds of habitats. For example in Finnish conditions such indicator species are vascular plants *Cardamine amara, Carex paniculata, Epilobium alsinifolium, E. davuricum, E. hornemannii, Juncus triglumis, Montia fontana, Petasites frigidus, Poa alpigena* and *Stellaria alsine*, and mosses *Brachythecium rivulare, Bryum weigelii, Chiloscyphus polyanthus, Oncophorus wahlenbergii, O. virens, Palustriella decipiens, P. falcata, Philonotis fontana, P. calcarea, Plagiomnium undulatum, Rhizomnium magnifolium* and *Trichocolea tomentella*. In springs rich fen species are also common and abundant, for example *Crepis paludosa, Eriophorum latifolium*, *Listera ovata*, *Sphagnum warnstorfii* and *Tomentypnum nitens* (Eurola et al. 1994, Warncke 1980).

3. TREATMENT OF SPRINGS IN FORESTRY PRACTICES AND WATER SUPPLY

Finland is a well known forest user and exporter. Forest management and loggings are provided in state land by a national service organization which is called Metsähallitus, and its local branches. In private land there is a separate forestry organization making forestry plans, giving advice and controlling forestry practices. State owns 44 % of forests in Kainuu province, forestry companies 14 %, municipalities 3 % and private forest lands cover 39 % correspondingly. The ownership of mires and small watercourses as well as springs is similar to the forests.

In earlier forest legislation springs were not protected in any way, but in 1970 the state gave instructions for forestry, in which it was forbidden to destroy springs in connection with forestry. Especially there were detailed guidelines for forestry drainage. These instructions were unfortunately not really taken into account in forestry practices, and springs were systematically destroyed.

Utilization of mires for forestry, agriculture and peat mining causes environmental changes: biodiversity decreases; increased leaching of nutrients and humus to watercourses; hydrological changes, increased floods; erosion especially in areas of thin peat on sand soil (Laine et al. 1995).

Finland's Forest Act from the year 1996 classifies the surroundings of natural small water courses and springs as especially important habitats, where forests may only be managed taking into consideration these special features. New drainage schemes are prohibited in areas covered by forest certification schemes, and ditching work of pristine mires is no longer subsidised. Immediate surroundings of springs, creeks, ravines, and small ponds are considered as Key habitats in forest legislation. Rich fens and spruce mires should not be treated with remedial drainage. Drainage waters should not be led directly into water systems, but first into protective buffer zones and silt traps. Forestry practices must be developed to reduce and prevent the leaching of nutrients (especially phosphorus and nitrogen) to slow down the process of eutrophication in water systems.

The region's smaller waters are recovering from the impacts of drainage schemes carried out in the 1960s and 70s. But drainage renovation schemes reverse this favourable trend. In large areas clearings of old ditches takes place. In some cases this activity damages small springs and springs fens which previously were damaged by foresters unintentionally or carelessly. It leads to a big loss of biotope diversity on local scale, causes simplicity of forest structure and changes the hydrological regime of surroundings. The responsibility for biodiversity of forest ecosystems in practice in the commercially exploited forests of Finland lies with the Forest Research Institute.

In addition to forestry, groundwater pumping for the water supply of towns and industry is threatening springs and their biota. Typically groundwater uptake decreases the flow of water in springs, causing diminishing of the area influenced by the water. A large number of springs have also been made as wells for domestic water supply in countryside.

Originally there have been thousands of springs in each province of Finland. In the southern half of the country almost all of them have been destroyed, mainly by ditching and turning the springs into wells. Here springs are preserved in natural state practically only in nature reserves, altogether about 10 in each province (Heikkilä R. 1992). (Fig. 1). A big amount of springs have been preserved in the northern half of the country only. Kuhmo is the southernmost area with a relatively high number of existing springs.

4. KUHMO CASE STUDY

Kuhmo is situated in Kainuu province in central eastern Finland. Forestry is one of the main factors of local economy. The total area of the province is 31 000 km^2, and a half of the area is in forestry use. Annual cuttings cover 200 km^2. The logged timber volume is estimated as 2 million m^3 per year. The main exploited trees are Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*).

In a detailed inventory in Kuhmo town, covering altogether 5300 km^2, 450 springs were found. 205 of them were in natural condition. Most of the damaged springs had suffered from forestry drainage of mires. In Kuhmo some 60% of mires have been drained for forestry. In some cases springs were destroyed, when a forest logging machine had been driven across the spring. Groundwater pumping has destroyed only two springs in Kuhmo. Hundreds of springs have been turned into wells for farms and summer cottages outside the town centre.

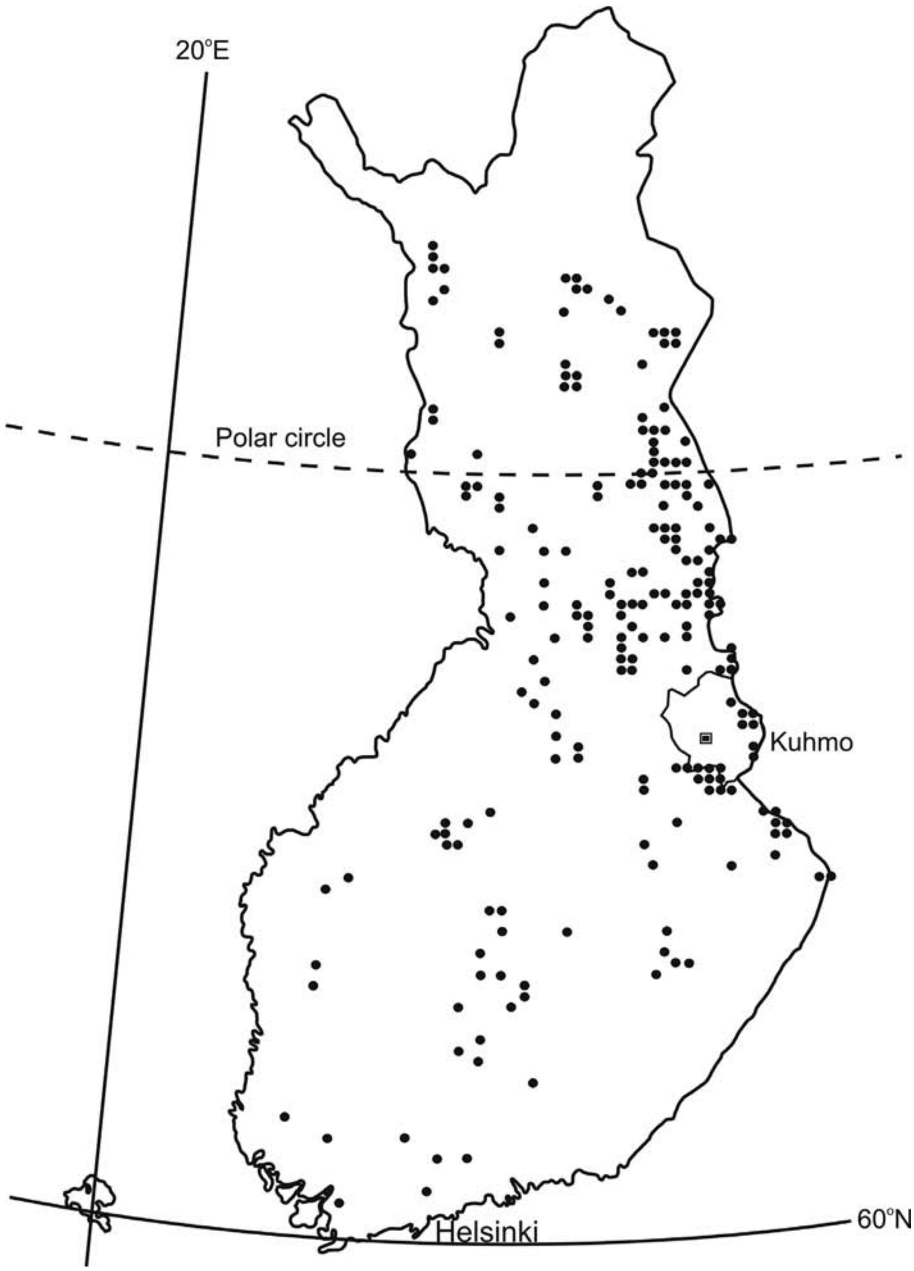
Like in southern Finland, springs in natural condition are concentrated mostly in nature reserves. For example, in Elimyssalo nature reserve, covering 8000 hectares, 35 natural springs have been found.

During the field observations in summer 2006 in eastern Kuhmo we recorded a few springs in surroundings of the clearcut area in Likosalo hill beside a drained spring area in Hetesuo mire. Both untouched and destroyed springs were studied. The number of species in virgin springs was about 40. In case of damaged hydrological conditions in dry springs, we found only 20 species as a mean. Bryophytes had been replaced by lichens in extremely disturbed sites.

5. RESTORATION AND CONSERVATION OF SPRINGS

Attempts for the restoration of damaged springs have been made in the province of North Karelia in easternmost Finland. In springs, which have been previously used as wells for water supply, the constructions have been removed so that the water can flow in a natural way. In forestry drainage areas the ditches have been dammed to raise the water table to the natural level.

Figure 1. The distribution of protected springs in Finland according to habitat inventories made by Metsähallitus (State Forest and Park Service) in 2002-2006. No data was available for northernmost Finland.



The result has not been as good as in the restoration of wells. However, the first experiences are promising, and in many cases the natural vegetation of springs has recovered within a few years after the restoration (Veli Lyytikäinen, personal communication 28.11.2006).

Springs and spring fens are very often habitats for rare vascular plants and endangered mosses. These specific features should be protected more strictly. We suggest that ecological education and increasing the awareness of biodiversity for land owners and forest loggers would be needed and helpful. There should also be inventories of springs so that the land owners would not destroy them accidentally.

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LAWN STRUCTURE OF TOPČIDER PARK

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Abstract: *Researches of covers park lawns in the Topčider park we found 78 plant species. Those plant species were classified in the quality groups (quality grass, bad grass, leguminous, herbaceous plants and trees and shrubs). Considering the fact that the highly ornamental lawns are formed with three or five plant species (Poa pratensis, Liolium perenne, Festuca rubra). High presents of less quality representatives of family Poaceae and some other families could be recognized as a bad solution. Such presents of weeds in highly ornamental plants reduce functionality of lawn which is caused with law grade of management and maintenance of lawns. Quality management and maintenance of lawns needs financial supports but also gives back good image of Topčider park.*

Key words: park lawns, lawn weeds, Topčiderski park

1. INTRODUCTION

Park and forest park have remarkable account in modern human subsistence. Numerous scientists, landscape architects, horticulturists, deal with the study and analysis of lawns from different aspects. All of them describe the lawns as the substrate or medium, which, unlike any other, suits the human feet in the best way, whether for work or for the active or passive recreation. The consistently green space of the lawns is agreeable to the eye and makes the landscape enjoyable for the man. In addition to the esthetical function, lawns are even more significant because they can stabilize the soil and suppress erosion, as well as enable further anchoring of the soil by trees and shrubs. The erosion control function of the lawns is significant both in non-urban and urban districts. Lawns also have a very significant reclamation function regarding the accumulation and purification of waste water, accumulation of heavy metals, reduction of temperature, reduction of noise effects, etc. Topcider park are also historical park. Bound of this park is settlement: Senjak, Dedinje, Kanarevo brdo, Rakovica, Vidikovac, Cerak, Banovo brdo. Thru the Topčider park flow Topčider river.

2. METHOD

The study presents results of the structure of grass-covered grounds in Topcider parks, residential settlements, office blocks and roads lawns in the territory of Belgrade city. Floristic and structural analyses are represented in Table 1, which contents 7 localities.

At the selected localities, the floristic composition was researched using the revised Braun-Blanquet (1964) method, after the Klap system and the method of the Institute of Arable Farming of the Agricultural Faculty in Zagreb (Šoštarić-Pisačić, 1968). The applied analysis was adapted to the research of lawns in Landscape Architecture and Horticulture. The greatest part of the research covered by this paper was performed during the period 1996-2000 (Stavretović 2002).

All plant species from Topcider park are classified in quality plant group (Turgeon, 1985; Stavretović, 1996; 1999):

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1. Quality grass
2. Low quality grass
3. Leguminous
4. Herbaceous plants
5. Tress and shrubs

The identification of flora of Belgrade lawns is based on abundant literature: Javorka & Czapody 1975; Hayek 1924-1933; Hegi 1926-1931; Tutin ed. 1964-1980; Jordanov ed. 1963-1989; Pignatti ed. 1982; Josifović ed. 1970-1977; Sarić & Diklić ed. 1989, etc.

3. DISCUSSION

Regardless their size and importance Topcider Park is not so much resort. Topcider Park is a natural part of park-forest Kosutnjak. Park have reach and versatile contents, also there have splendid plant material, as a protected tree trunk of species *Platanus acerifolia*.

According chemical analysis, soil reaction in park is lightly alcal, contents of nutrients is low, mechanical analysis indikate soil with large participation of dust and clay (Vratuša, 1999).

In the study area, we identified 78 plant species, their character in this park was qualified by vicinity of park-forest Košutnjak. Dominant species in Topcider park by quality plant group (Turgeon, 1985; Stavretović, 1996; 1999) are herbaceous plants 56,41% (*Bellis perennis, Lysimachia nummularia* etc.). Number of quality plant is 11 (14,1%).

On the location 4 (Table 1.), moisture and half shadow lawn is dominated species *Cynosurus cristatus* with species *Lysimachia nummularia* and *Prunella vulgaris*. Aperture growth of plant species in lawn is 15,7 cm, and aperture covered of lawn in Topcider park is 60%. The main reason of low covered land in Topcider park is attendance of plant species with large landline organ (leaf, stem, flower…), plant like *Hypochoeris radicata, Rumex crispus, Taraxacum officinalis* etc.

Table 1. Locality: Topčider park

	No.	Area (m2)	150	50	70	40	220	50	100
No.	species	Growth (cm)	10	10	25	15	25	10	15
species	in	Covered (%)	80	fug	60	30	80	fug	60
	group	Incline (n)	/	/	/	/	1	/	/
		Exposure	/	/	/	/	/	/	/
		Date	1997	1997	1997	1998	1998	2000	2000
A	B	No. species in location	34	19	27	21	32	7	28
		No. location	1	2	3	4	5	6	7

I Quality grass:

1	1	Lolium perenne	1.2		1.2	R	1.2	+	R
2	2	Festuca rubra	1.2		R	+	1.2		
3	3	Poa pratensis	R	R				R	R
4	4	Poa nemoralis	R		R	+			
5	5	Agrostis alba	+		R				
6	6	Poa trivialis	R	R					
7	7	Festuca pratensis					2.2		
8	8	Cynosurus cristatus				2.2			
9	9	Agrostis vulgaris				+			
10	10	Festuca heterophylla					+		
11	11	Festuca ovina					R		

II Low quality grass

12	1	Agropyrum repens	+		1.2		2.2		
13	2	Poa annua	R	R	+				
14	3	Dactylis glomerata				R	R		R
15	4	Hordeum murinum	R					R	
16	5	Bromus mollis							+
17	6	Bromus sterilis					R		
18	7	Bromus tectorum					R		
19	8	Lolium multiflorum			R				
20	9	Sorghum halepense					R		
21	10	Cynodon dactylon		R					
22	11	Brachypodium pinnatum				R			

III Leguminous

23	1	Trifolium repens	1.1		+		+	R	R
24	2	Medicago lupulina	+	+		R	R		1.1
25	3	Trifolium pratense	R		R		R		+
26	4	Coronila varia							+
27	5	Medicago falcata							R
28	6	Vicia cracca							R
29	7	Astragalus onobrichis							R
30	8	Lotus corniculatus							R

IV Herbaceous plants

31	1	Bellis perennis	1.1	R	R	R	2.1	R	3.1
32	2	Lysimachia nummularia	+		1.1	1.1	+		
33	3	Hypochoeris radicata	1.1		R		R		2.1
34	4	Carex divulsa	R		1.1	R	R		
35	5	Prunella vulgaris	R	R	+	+			
36	6	Rumex obtusifolius	+		R		R		R
37	7	Plantago lanceolata	R		R		R		+
38	8	Convolvulus arvensis	R				+	R	R
39	9	Roripa silvestris	R	R	R	R			
40	10	Ranunculus repens	2.1		1.1		R		
41	11	Potentila recta	1.1		R		+		
42	12	Achillea millefolium	+	+					+
43	13	Gallium molugo				R	R		R
44	14	Taraxacum officinale	R				R	R	
45	15	Oxalis acetosela	R	R			R		
46	16	Plantago media	R	R			R		
47	17	Sonchus arvensis		R	R				R
48	18	Carex hirta	R		1.1				
49	19	Ranunculus scardous					R		+
50	20	Juncus articulatus		R	R				
51	21	Capsella bursa pastoris	R	R					
52	22	Veronica persica	R	R					
53	23	Leontodon hispidus					R		R
54	24	Rumex crispus		R	R				
55	25	Urtica dioica	R						R
56	26	Crepis pulchra							+
57	27	Carex vulpina				+			

IV Herbaceous plants

58	28	Glechoma hederacea	+						
59	29	Potentilla argentea							R
60	30	Leontodon crispus					R		
61	31	Cirsium arvense					R		
62	32	Veronica serpyllifolia				R			
63	33	Viola canina				R			
64	34	Geranium molle		R					
65	35	Myosotis arvensis							R
66	36	Rumex acetosela			R				
67	37	Ranunculus polyanthemos			R				
68	38	Prunella laciniata			R				
69	39	Euphorbia cyparissias	R						
70	40	Stenactis annua		R					
71	41	Polygonum aviculare		R					
72	42	Lapsana communis				R			
73	43	Sonchus oleraceus							R
74	44	Duchesnea indica				R			

VI Tress and shrubs

75	1	Populus alba					+		
76	2	Acer campestere				R			
77	3	Rosa canina							R
78	4	Aesculus hypocastanum				R			

4. CONCLUSION

The role funcktion of lawn in Topcider park is estetic. In the Topcider Park we observed wary much weed, which is characteristic of low intensity of management and maintenance. Menu species in this park have not characteristics for park lawn (dark green color, uniformity, growing, adaptability for low cutting, texture of leaf). With adequate measures of maintenance, all mentioned surface covers can fulfill all necessary functions.

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STRATEGY OF SUSTAINABLE DEVELOPMENT-KEY STUDY THE VAELLY OF JADAR RIVER

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Abstract: *In the framework of study of the Jadar river management, the research of biological and hydrological characteristics of the river is performed. On the basis of floristic investigation of riparian zone of the Jadar river, existent plant species and communities, life forms were identified, and phytogeografical analysis was done. From the other side, in the framework of investigations of morphological and hydraulic characteristics of the river, the primary factors of riparian zone management - morphometric variation, hydraulic resistance and stability of river bank are considered..*

Taking into consideration all actual postulates, from the aspect of biodiversity conservation and ecosystem improvement in the Jadar valley, basic principles for river management were defined. In the river management concept, necessity of river corridor extension has to be considered. This is the only way for reach of essential improvement of the Jadar valley, taking into account importance of river banks and riparian zones as "ecological recourses". In extended river corridor forming of complex biota with specific mosaic sites should be initiated.

Key words: Jadar river, riparian zone, biodiversity

1. INTRODUCTION

The European parliament accepted "The water frame directive" in 2000, which emphasize the contemporary concept of management, protection and use of water in nature implies comprehension of ecological problems. This directive has become a basis for all activities in the water field in European countries. In the directive, technical and biological disciplines are so strong connected that it is impossible any activities in water field without multidisciplinary approach.

Considering wide spread in nature, watercourses have fundamental importance for the environment. Hydrological potential of the river basins and hydraulic capacity of the river bad enable the water supply of the riparian zone. In natural state of river basins and watercourse the conditions for development specific aquatic and riparian ecosystems were created. These ecosystems distinguish significant biodiversity. Therefore of the great importance is taking care of these ecosystems and conditions for their subsistence in the presence of water economic activities in the watershed and river watercourses. It should emphasize that biodiversity conservation is concerned as one of the most important postulates in world science.

The river banks and riparian zones have a great importance for environment and because of that they are considered as "ecological resource". In these zones, complex of biotope with mosaic of specific sites is formed. In this frame, the wetlands have particular importance. According to contemporary conception, the watercourses have a role of „transported vector" in the process of energy and matter transferring along watercourse (Friedman, Auble, 2000). At low and medium water, transported processes are predominantly longitudinal, and at high water they are longitudinal and lateral. This lateral component has significant ecological importance.

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2. METHOD

The basic method of researches consisted the research of biological and hydrotechnical characteristics of investigated region of the Jadar river.

Within the floristic diversity researches of the Jadar riparian area, plant communities and species were identified and phytogeographic analysis and analysis of biological spectra were done.

On the other hand, within researches of morphological and hydraulic characteristics of watercourse, the basic factors of river channel management and riparian zone (the variation of morhometric parameters, hydraulic resistance and the stability of the river banks) were considered.

3. DISCUSSION

The intensive anthropogenic influence has crucial importance on floristic structure in the Jadar river channel. The anthropogenic influence is noticeable through non methodical and irrational exploitation, but also through forming of dumping sites and the other waste material. The alluvial arable soils, on which forest vegetation was developed, are converted into agricultural lands. The use of soils in agricultural purposes has generated introduction of different weed and ruderal species, what more has contributed to degradation of parent forest communities. At this area, fragments of forest and meadow communities which are common along river watercourses are present scarcely, often converted into waste disposals, dumping sites and dredging locations.

River management

Considered reach of the Jadar river is characterized by the natural state of the river, without the water engineering works. The river alignment consists of the series of sharp bends. The river morphology is heterogeneous, with variable cross-sections. The river bed is covered by vegetation, which produces the high flow resistance. The channel capacity is limited and insufficient for the high waters of the river. Thus, during the floods, the riparian zone of the river is inundated. The floods occur frequently, representing the main river management problem. So, the principal goal of river management is the flood control. The approach to the flood control should be based on the harmonization of water engineering and environmental principles.

From the point of view of harmonization of water engineering and environmental principles, it is very important to take into consideration the ecological role of the floodplain. This zone is considered as "ecological resource", having the key role for the survival of riparian ecosystem. On the other hand, the hydraulic function of the floodplain is also important, because of the retention capacity of this zone. From the point of view of water quality, the floodplain is also important, having the role of the biological filter for decrease of water pollution.

According to the contemporary concept of the river management, the river corridor, encompassing the floodplains on both sides of the river, should be as wide as possible. The width of the river corridor is limited by the rural settlement and activities in the riparian zone.

Harmonization of the water engineering and environmental principles is also important from the point of view of bank stability. The natural banks of the Jadar river is covered by trees and brushwood, which have a role of bio-armoring. Thus, the river regulation works should include the survival of the natural vegetation of the river banks.

Floristic diversity of the Jadar riparian area

The area of the Jadar River belongs to Moesian phytogeographic province, wider Balkan and Balkan- Apennine floral elements (Gajić, 1984). The clime is continental in the Moesian phytogeographic province. At these regions, the influences of Mediterranean and oceanic clime encounter. The mean January temperature is above 0°C, the mean annual temperature is between 10°C and 11,5°C. Maximum of rainfall is by the end of spring and by the start of summer, and the minimum is in the winter. The winters are very sever with big extremes.

In vegetation sense, the forest community *Quercetum frainetto-cerris* characterizes Moesian phytogeographic province. It is climate community of eastern, continental part of Balkan. Beech forest (*Fagetum montanum*) is characteristic of the Moesian province, also. The soils in this province are different.

In riparian zone, the vegetation is under intensive influence of oscillation of water stage height and status of erosion processes. This hypothesis is particularly important for humidity of rhysosphere. Plant species developed in this zone tolerate extremes in aqueous and air diapason. Because of that the vegetation of riparian zones compose of specific plant species which are adapted on such site conditions, what means that in floristic diversity it is impoverished.

From floristic and vegetation aspect, the communities of willow and poplar give attribute to all area.

Along the watercourse of the Jadara river, the communities that could be isolated are:

- Ass. *Salicetum triandrae* Marc.,
- Ass. *Salicetum albae inundatum* Jov.,
- Ass. *Rubeto Salicetum albae* Jov.,
- Ass. *Rubetum caesiae* prov.,
- Ass. *Populeto-Salicetum* Raj.,
- Ass. *Populetum albo-nigrae* Slav.,
- Ass. *Festucetum pratensis* Gaj.

At investigated localities, as facies es, species of the other plant communities are present. They did not succeed to develop until the end, the most often because the sites are bound with waste material of different origin. One of such communities which is developed on extremely degraded sites is *Sambucetum ebuli*. Along riparian zone of the Jadara river, 62 plant species within 27 families are described. Systematic review is shown in text that follows.

Considering the fact that the sites of investigated regions are quite uniform, described plant species is significant. The plant species development is enabled by sites degradation and appearance of weed and ruderal species. At the other hand weed and ruderal species which are present on these sites are dense composition, make turf forms in which the other plant species can develop hardly.

If diversity of flora is considered in broad sense, it could be noticed that normal progressive phases of appropriate plant communities can not be expected in the future. It is possible to expect only regressive phases with invasive species which have small demands for light, quantity of humus in the soil and place.

One of the important indicators of biological diversity is life forms spectrum. The life forms are reflection of complex influence of environmental conditions on plant communities, namely whereby them we establish local ecological factors which influence on composition and structure of plant communities, what enables comparison with other communities, at the same or different localities. On the investigated areas group of hemicriptophyta is dominant (28,33%). Groups of phanerophyta (26,66%) and therophyta (23,33%) have high presence degree. Than criptophyta (18,33%) follows. The smallest number of species belong to group of chamaephyta (3,33%).

At the area along of watercourse of the Jadar river, 20 floral elements from diferrent floral regions are described. The Eurasian (45,00%) and Middle European (26,66%) floral elements are dominant. Adventive (10,00%) species and Cirkumpolare (8,30%) floral elements follow. The Submediterranean (5,0%), Subatlantic (3,3%) floral elements and floral elements of northern areas (1,7%) have the smallest percentage.

4. CONCLUSION

The intensive anthropogenic influence has crucial importance on floristic structure in the Jadar river channel. The alluvial arable soils, on which forest vegetation was developed, are converted into agricultural lands. The use of soils in agricultural purposes has generated introduction of different weed and ruderal species, what more has contributed to degradation of parent forest communities.

Along riparian zone of the Jadara river, 62 plant species within 27 families are described. Considering the fact that the sites of investigated regions are quite uniform, described plant species is significant. If diversity of flora is considered in broad sense, it could be noticed that normal progressive phases of appropriate plant communities can not be expected in the future. It is possible to expect only regressive phases with invasive species which have small demands for light, quantity of humus in the soil and place.

From the aspect of biodiversity conservation and ecosystem enhancement in the Jadar valley, taking into account all the modern postulate of river management, the guidelines of river management were defined. The concept of river management must take into account the necessary extension of the river corridor. Only in this way it is possible to realize the essential ecological enhancement of the Jadar valley, bearing in mind the significance of the river banks and the riparian land as the "ecological resources". In the extended river corridor, the establishment of a complex biotope should be initiated with a mosaic of specific sites.

In the case of the Jadar valley, extension of the river corridor is possible by reduction of agricultural area in riparian zone. On the other hand it should not allow construction of the levees in the proximity of the river banks. The wider floodplanes have important ecological function and hydraulic effect.

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MAPS ON SERPENTINE-SOIL AND FLORISTIC INVESTIGATIONS

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Abstract: *Based on the international criterion IUCN-WMC, the territory of our country, together with the mountainous regions of Bulgaria, is one of 6 European centres of biological diversity, i.e. one of 158 world centres. The region of Serbia is characterised by the abundance, heterogeneity and diversity of plant species, because its flora consists of about 4182 plant taxa (Stevanović, 1995). Among them medicinal plant species are also much spread.*

The quality of medicinal plant active substances is the most important factor for their harvesting and usage, especially for that grown on serpentine parent rock.

A comparative investigation of medicinal plant species floristic structure, ecological indexes and chemical soil characteristics was carried out in three serpentine localities in Serbia: Mt. Kosmaj (meadow association Festucetum vallesiacae), Mt. Divčibare (meadow associations Nardetum strictae and Poa molinieri-Plantaginetum holostei) and Mt. Goč (endemic community Helleboro serbicae-Danthonietum calycinae). The aim of these investigations was to define the possible limiting and hazardous factors, for the development and exploitation of medicinal plants.

Summarising of gathered results allows identification of medicinal plants, which could be collected on these localities.

Key words: MAPs, serpentinite, soil characteristics, exploitation

1. INTRODUCTION

Many authors have paid attention to medicinal plants, as an important potential of forest and meadow ecosystems in Serbia (KORAĆ et al., 1987; GAJIĆ et al., 1989, 1990, 1992; GAJIĆ & OBRATOV, 1992; SVILIKIĆ et al., 1993; OBRATOV 1993; OBRATOV & ĐUKIĆ, 1966, 1997; DAJIĆ et al., 2000, OBRATOV-PETKOVIĆ et al., 2002; OBRATOV-PETKOVIĆ & POPOVIĆ 2003, OBRATOV et al. 2004, 2004a, OBRATOV et al. 2005, OBRATOV et al. 2006.), etc. The use of medicinal plants is limited by the quality of active substances they contain, and the quality of medicinal raw material depends on many ecological factors which affect the photophilous, but also the geophilous plant organs (LOMBINI et al., 1999). The distribution and the degree of presence of medicinal plants are directly correlated with the ecosystem conditions, especially the soil quality.

Three following areas in Serbia were chosen in order to estimate the relations between the habitat characteristics and the presence of medicinal plants: Mt. Kosmaj (northwest Serbia), Mt. Goč (central Serbia), and Mt. Divčibare (central part of western Serbia). The parent rock of these localities is serpentine. Serpentine is characterised by the presence of a smaller number of plant species in comparison with limestone (e.g. GREEN et al., 2003; HARRISON et al., 2000; BATIANOFF & SINGH, 2001). The calcifuges plant species mainly grow on serpentine type of bedrock, due to pH (5.5-8), higher concentration of Mg, Cr, Ni, Co, and lower concentration of essential macronutrients, such as Ca, K and P.

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The changes in the soil, as a result of numerous processes, fare gradually and are hardly noticeable during the shorter periods affecting the ecosystem functions. Therefore, the recent studies and analyses from the aspect of ecological soil quality, as an important element of sustainable soil management, have been intensified. According to VANMECHELEN et al. (1997), the analyses of ecological soil quality address the function of accessibility of elements of plant nutrition (nitrogen, phosphor, and alkaline cations), sensibility to acidification and accessibility of heavy metals.

Our study predominately deals with estimating of responses and conditions of medicinal plants populations developed at particular localities related to processes of the chemical degradation of soil. This kind of investigation has been performed in order to identify the potential for further exploitation of medicinal plants.

2. MATERIAL AND METHODS

The investigations were carried out in three serpentine areas in Serbia: Mt. Kosmaj (central Serbia), Mt. Divčibare (central part of western Serbia), and Mt. Goč (central Serbia), where soil types, floristic composition and ecological indexes were analysed.

The geological layer of these localities is mostly serpentine.

The climate of these regions is temperate continental.

The soil samples were taken from fixed depths: 0-10 cm, 10-20 cm and 20-40 cm in five repetitions. The soil analysis was focused on the group of basic attributes, including morphological properties, analysis of standard chemical parameters and general pedological features. Methodology for soil properties analyses was in accordance with the JDPZ standards (1966), harmonised with the criteria of ICP methodology (IPC Forest Manual, Part III, Soil Sampling and Analysis, Hamburg, 1998).

Parameters and reference methods for soil analyses:

- pH ($CaCl_2$) - UNEP-UN/ECE Method 9103SA, Reference method LABEX 8703-01-1-1; SO/TC190/SC3/GT8
- $CaCO_3$ – UNEP-UN/ECE Method 9102SA, Reference method AFNOR X 31 – 105 by calcimetar
- Total N - UNEP -UN/ECE Method 9105SA, (wet oxidation Kjeldakl-method – K_2SO_4 : $CuSO_4$ 1: 10)
- Org. C – UNEP -UN/ECE Method 9104SA, Reference method ($K_2Cr_2O_7$, H_2SO_4); for organic layer by Ansttets method with modification Ponomareva and Plotnikova.

Indicator values for accessibility of nitrogen and acidification status are calculated according to equation in Table 1. (Vanmechelen et al. (1997).

Table 1: Calculation of indicator values of the soil ecological quality

Indicator values	Basic equations
Availability of nitrogen, IN	IN = Nc + RC/N + RCZ
Status of acidification, IAS	IAS = pHc + BSc + (CaCO3)c

The parameters of the equations above are: Nc – cumulative value of class of nitrogen concentration in mineral layers of soil; $R_{C/N}$ – cumulative value of C/N relation in organic and mineral layers; R_{CZ} – value for adequate climate zone; pHc – cumulative value of class of pH in organic and mineral callow layer; (CaCO)c - value of class of CaCO3 concentration in mineral callow layer.

The general floristic study included the whole flora of Goč, Divčibare and Zlatibor, whereas specific ecological investigations were conducted on the experimental plots during three years (2002-2005).

The phytocoenological investigations were performed by utilisation of the composite scale of the number and the degree of coverage after WASTHOFF-VAN DER MAAREL (1973), ranging from 1-9.

The identification of medicinal plants is performed according to SARIĆ (1989).

Ecological indices of humidity (F), soil acidity (R), nitrogen quantity (N), light (L), and temperature (T) are according to the formula:

$$\sum_{i=1}^{n} N_{i,k} * EO_i$$

where $N_{i,k}$ represents the number of species in a community, and EO_i is the ecological optimum for the given species (KOJIĆ ET AL. 1997). The average values of ecological indices are calculated in the Discussion section.

3. RESULTS

3.1. Soil research

At the locality Beli Kamen (Mt. Kosmaj), rendzina on flysch is described; on the locality Kraljev sto (Divčibare) eutric humus-siliceous soil, and eutric cambisol is described at the locality Ravnine on Goč. Two soil profiles were opened on each locality. The average values of chemical characteristics of study soils are shown in Table 2.

Table 2: Chemical properties of studied soils

Locality	Layer (cm)	pH (CaCl2)	BS %	C g.kg-1	N g.kg-1	C/N	CaCO3 %
Kosmaj – Sedlar	Organic layer	6,0		84,7	5,5	15,4	-
	0-10	6,5	83,05	63,9	6,2	10,3	19,7
	10 - 20	6,9	86,18	23,1	2,0	11,5	> 25
Divčibare Kraljev sto	Organic layer	5,0		110	7,5	14,7	-
	0-10	5,66	83,7	94,0	7,3	12,8	-
	10 - 20	5,77	88,7	44,8	3,6	12,4	-
Goč - Ravnine	Organic layer	4,70		166,5	9,0	18,5	-
	0-10	6,30	99,83	27,7	2,8	9,9	-
	10 - 20	6,87	99,9	18,2	2,5	7,3	-

Indicator values of some parameters were calculated by the equations (Table 1) based on the analysis of soil chemical characteristics. The mean values of indicators for the availability of nitrogen, sensitivity to acidification are shown in table 3.

Table 3: The mean values of indicators of availability and acidification status

Indicator values	Soil type		
	Kosmaj	Divčibare	Goč
	Rendzina	Eutric humus-siliceous	Eutric cambisol
IN	14,0	13,3	14
ISA	16	19	13

3.2. Floristic research

3.2.1. Locality Kosmaj

The largest area of Kosmaj is covered by forest communities which are significantly thinned, degraded and devastated. The most widespread are beech forests (Fagetum montanum) which descend occasionally down to 180 m a.s. l. Oak forests are mainly represented by the association Quercetum confertae-cerris which is situated on gently sloping sites on brown forest soil. Meadows occupy a smaller a rea. In forest and meadow associations of Mt. Kosmaj, the total number of identified species is 557 species from 51 families. Kosmaj is characterised by relative floristic poverty, mainly resulting from both the impact of bedrock (mainly serpentine) and site degradation.

The meadow community Festucetum vallesiacae is analysed on Kosmaj. On the this type of meadow community the most frequent medicinal plants are *Galium verum, Calamintha vulgaris, Rubus caesius* and *Centaurium umbellatum.*

3.2.2. Locality Divčibare

On Divčibare the largest part of investigated area is under pastures and meadows, followed by pine forest, and quite minute areas are under beech-fir and birch forests. Among them ass. Danthonietum calycinae and Nardetum strictae are the most dominant types of the communities.

The most f requent medicinal s pecies are *Galium verum, Euphrasia stricta* and *Teucrium montanum.*

3.2.3. Locality Goč

A specific endemic association Helleboro serbicae-Danthinietum calycinae is developed at the locality Ravnine on Mt. Goč serpentinite. This association consists of altogether 76 species of which 22 species are medicinal plants. The association is located in the reclamation unit and it belongs to the degradation phase of the forest community Quercetum montanum serbicum.

The most frequent medicinal species are *Achillea millefolium, Sanguisorba minor, Anthyllis vulneraria* and *Stachys officinalis.*

Table 4: Medicinal plants - abundance and ecological indices for moisture (F), soil acidity (R), nitrogen (N), light (L), temperature (T) on the three investigated localities

Plant species	Kosmaj	Divčibare	Goč	F	R	N	L	T
	A B U N D A N C E							
Galium verum L.	7	7	3	2	4	2	4	3
Achillea millefolium L.	3	5	9	2	3	3	4	3
Calamintha vulgaris Druce	7	2	7	3	4	2	4	3
Euphrasia stricta Wolff.	2	7	5	2	3	2	3	3
Sanguisorba minor Scop.	2	3	8	2	4	2	4	3
Anthyllis vulneraria L.	2	3	8	1	4	2	4	3
Centaurium umbellatum Gillib.	5	2	5	3	3	3	4	3
Centaurea jacea L.	2	3	7	3	3	3	4	3
Euphorbia cyparissias L.	2	5	3	2	3	2	4	3
Hypericum perforatum L.	3	5	3	2	3	3	3	3
Taraxacum officinalis Weber	3	3	5	2	3	3	4	3
Stachys recta L.	3	5	2	1	4	2	4	3
Agropyrum repens (L.) Beauv.	2	2	7	3	3	4	4	3
Stachys officinalis (L.) Trevis.	2		9	2	3	3	5	3
Viola tricolor L.	3	5	3	3	3	3	3	3
Filipendula hexapetalla Gilib.	2	2	7	2	3	2	4	4
Primula veris subsp. columnae Huds.	2		8	3	4	3	5	3
Rubus caesius L.	8		2	4	3	2	3	3
Potentilla erecta (L.) Rausch.	2		8	3	3	2	3	2

Erica carnea L.		5	5	2	4	2	4	4
Origanum vulgare L.	7		2	2	3	2	3	3
Potentilla erecta (L.) Rausch.	2	5	2	3	3	2	3	2
Teucrium montanum L.		7	2	1	5	1	4	3
Anemone nemorosa L.	2		7	3	3	3	2	3
Medicago falcata L.	3	3	2	2	4	2	4	4
Prunella vulgaris L.	3		5	3	3	3	4	3
Thymus pulegioides L.	3	2	3	2	3	1	4	3
Thymus moesiacus Bernh.			8	1	3	2	3	5
Solidago virgaurea L.	2	3	3	3	3	3	2	3
Ranunculus bulbosus L.			7	2	4	2	4	3
Campanula glomerata L.	5		2	2	4	3	4	3
Teucrium chamaedrys L.	5		2	1	4	1	4	3
Primula acaulis (L.) Gr.	2		5	3	3	3	3	4
Plantago lanceolata L.	3	3		3	3	3	3	3
P. media L.		3	3	2	4	2	4	3
Colchicum autumnale L.			5	3	3	3	3	3
Rumex acetosa L.	2	3		3	3	3	4	3
Cichorium intybus L.	3		2	2	4	3	5	4
Agrimonia eupatoria L.	3		2	2	4	3	4	3
Potentilla recta L.	3	2		1	3	2	4	5
Cynanchum vincetoxicum Pers.		5		2	4	2	3	3
Hieracium pilosella L.		5		2	3	1	4	3
Cardamine pratensis L.		5		4	3	3	3	2
Achillea asplenifolia Vent.		3		3	3	1	4	4
Sedum acre L.		3		1	3	1	5	3
Hypericum barbatum Jacq.		3		3	4	2	3	3
Ranunculus bulbosus L.		3		2	4	2	4	3
Angelica silvestris L.			3	4	3	3	3	3
Juniperus communis L.			3	2	3	2	4	3
Mentha arvensis L.	3			4	3	3	4	4
Artemisia vulgaris L.	3			3	3	4	4	3
Clematis vitalba L.	3			3	4	3	3	3
Matricaria chamomilla L.	2			3	3	3	4	4
Eupatorium cannabinum L.	2			4	4	3	3	3
Verbascum phlomoides L.	2			2	4	3	4	5
Lysimachia vulgaris L.	2			4	3	3	3	3
Anchusa officinalis L.	2			2	3	3	4	4
Campanula rapunculus L.	2			2	4	3	3	3
Althaea officinalis L.	2			3	3	3	4	5
Digitalis lanata Ehrh.	2			2	5	2	4	4
Total/Average				3.2	2.6	2.6	4.7	2.4

4. DISCUSSION

The comparative analysis is based on the results of floristic investigations of medicinal plants, their ecological indexes and soil characteristics. Most of the attempts to identify and to analyze the so-called plant-available fractions of various nutrients with different extractants or incubation techniques have not been very successful (REHFUESS & PRIETZEL,1998). The next step is to use the concentrations or the contents of total nutrients in the soils as fertility indicators.

According to VANMECHELEN ET AL. (1997), indicator values for nitrogen, for all investigated soil types belong to class of low accessibility (12.1-17.5). Indicator values for nitrogen represent total potential of organic material that in certain climatic conditions may be potentially used by plant. However, the nitrogen quantity which will be used by plants depends also on the conditions of nitrogen loss from the soil.

In the case of rendzina at the locality Sedlar (Kosmaj Mt.), as well as eutric cambisol at the locality Ravnine (Mt. Goč), the reaction of soil samples is neutral and the conditions for nitrogen loss are more favourable. At the locality Kraljevsto (Divčibare) in the case of eutric humus-siliceous the reaction of soil samples is weakly acid and the conditions for nitrogen loss are favourable also.

Regarding the ecological index of nitrogen (2.60), the value of the most frequent species of the community is 2, e.g. *Galium verum, Rubus caesius,* and *Origanum vulgare.* Another group of species has value 3: *Campanula glomerata, Achillea millefolium, Hypericum perforatum, Clematis vitalba,* etc., while *Teucrium chamaedrys* has value 1. There are no species with the index above 3. This might be related to fairly small needs for nitrogen.

Soil acidification is an important link between air pollution and the damage to the terrestrial and aquatic ecosystems. This process has been related to forest dieback via its effect in the tree root zone, but also the ability of soil to buffer acid deposition as a key factor in regulating the long-term surface water and groundwater acidification. Soil characteristics, such as pH or carbonates, may change according to the specific characteristics of the contamination source. Sorption patterns depend on the concentration of heavy metals (SASTRE, 2006).

Status of acidification is a parameter for determination soil sensitivity according to acidification. High soil sensitivity is, first of all, a consequence of low saturation by bases and leaching of exchangeable alkaline cations. Indicator values I_{AS} of investigated soils are vary low (> 12). This value indicates very low sensitivity to this process, which is typical for the class with very high pH-values (>6.0 pH).

The average ecological index of soil acidity (R) of the study plants (2.60) shows the same effect. Ecological analysis of species of this community shows that there are no species with ecological index of acidity of 1 or 2, many species have index 3, and only the species *Digitalis lanata* has index 5. Medicinal species with high abundance and potential preference for alkaline soils are: *Teucrium montanum, Calamintha vulgaris, Galium verum, Cichorium intybus, Agrimonia eupatoria, Campanula glomerata, Teucrium chamaedrys, Primula veris, Anthylis vulneraria, Sanguisorba minor, Ranunculus bulbosus,* etc.

Hydrothermic conditions of the soil influence significantly the processes of ammonization, ammonification and nitrification. There is a correlation between hydrothermic conditions of the soil and the ecological indices of plants for moisture (F), light (L) and temperature (T). The average value of ecological index of moisture (F) shows the predominant presence of sub mesophytes (3.2) in all communities. Ecological index of light (L) shows the dominance of helophytes (4.7), and ecological index of temperature (T) shows that the plants are between frigoriphylic and mesotermic (2.4).

The analyse of floristic composition show that similar plant species grow on all the investigated areas.

The edaphic specialization and plant adaptation to serpentine soils is phylogenetically and geographically widespread (BRADY ET AL. 2005). Plant species adapted to serpentine soils often posses somewhat distinct morphology from closely related species not adapted to serpentine sites (COOKE, 1994).

On Mt. Kosmaj, Divčibare and Goč, serpentinite is not the only geological layer. There are small areas composed of limestone. Morphologically, we compared the medicinal plants sampled on serpentinite with the same species sampled on limestone and noticed the differences between them. The turfs of plants growing on serpentinite are less compact than those of plants growing on limestone (Teucrium chamaedrys, Anthyllis vulneraria, Prunella vulgaris, Thymus pulegioides etc.); the plants growing on serpentinite are smaller than the same species on limestone; the leaves of plants on serpentinite are smaller, covered with more hairs and many of them are grey-green in comparison with the plants on limestone; some of the sampled plants on serpentinite have better developed roots (Calamintha vulgaris, Achillea millefolium, Hypericum perforatum, Primula vulgaris etc.) than on limestone.

Biologically, serpentine sites frequently host a depauperate flora compared to the surrounding regions. Sparse plant cover also encourages erosion and promotes elevated soil temperature (KRUCKEBERG, 2002). Each of these factors poses an additional stress to plant life. Together, the chemical, physical and biotic components of the edaphic factor produce the "serpentine syndrome" (JENNY, 1980). This combination creates a patchwork of microhabitats in the serpentine grassland that results in variation in species structure within small area (MC CARTEN, 1992).

At the same time, high levels of genetic differentiation were detected between the populations within one region, as well as between the populations of different regions (PATTERSON & GIVNISH, 2004). Plant populations growing on serpentine have strong divergent selection, the subsequent genetic differentiation of the populations renders them reproductively isolated, and in extreme cases, results in ecological speciation (SCHLUTER, 2001).

BOYD & MARTENS (1998), after BRADY AT AL. (2005), offer three theories to explain the "preadaptive" nature of nonserpentine populations to serpentine conditions: a) high rates of gene flow from serpentine to nonserpentine populations bring serpentine tolerance alleles into latter populations, b) a constitutive serpentine adaptive trait presents little or not cost to a plant, c) a serpentine adaptive trait is adaptive for more than one function.

Prezygotic isolating mechanisms between plant species include shifts in flowering time, a switch to primarily self-fertilization from out-crossing, and alternations in flower morphology that affect pollinator attraction and/or visitation (MACNAIR, 1998). Peak flowering time in serpentine and nonserpentine populations differs significantly (WRIGHT ET AL, 2005).

5. CONCLUSION

The comparative analysis of the three investigated localities, based on the research of soil, floristic composition of medicinal plants and ecological indices, shows the existence of correlative relations.

The soil research on the locality Sedlar (Mt. Kosmaj), enabled to identify rendzina on flysch sediments, on the locality Ravnine (Mt.Goč) eutric cambisol, and on the Kraljev sto (Divčibare) eutric humus-siliceous. All of these soil types distinguish with relative unfavorable of macroelements content.

On the basis of soil studies, it can be concluded that nitrogen shows low availability, what is limited factor. With the increase of values for nitrogen in the soil, species which have bigger ecological index for nitrogen appear in the community. Such plants, with medicinal attributes are: *Campanula glomerata, Centaurium umbellatum, Achillea millefolium, Mentha arvensis, Hypericum perforatum* etc.

Analyzing the soil acidification in correlation with ecological index for acidity in plants, it can be concluded that with increase of acidity, total ecological index for acidity of plants are increased in all studied communities. From medicinal plants that have enhanced index for acidity it should emphasize: *Galium verum, Calamintha vulgaris, Teucrium chamaedrys, Cichorium intybus* etc.

Hydrothermic conditions of the soil and plant species in all communities show the predominant presence of submesophytes, helophytes and plants between frigoriphylic and mesotermic.

Summarizing the previous conclusions it is possible to select the plants which could be used for collecting on these localities. They are in the category of indifferent species in relation to basic ecological index, and with enchanted numerous, sociality and presence degree.

The following medicinal species could be recommended for the purposes of harvesting from the wild: *Calamintha vulgaris, Centaurium umbellatum, Achillea millefolium, Mentha arvensis, Thymus pulegioides, Hypericum perforatum, Galium verum, Cichorium intybus, Origanum vulgare, Teucrium chamaedrys, Artemisia vulgaris, Stachys recta, Potentilla erecta, Thymus moesiacus* and *Euphrasia stricta.*

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USAGE AND PROTECTION OF HERBACEOUS PLANTS IN NATIONAL PARK "TARA"

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Abstract: *The National Park "TARA" contain a great number of herbaceous plants, whose protection and directed use have ecological, scientificall, educational, economical and decorative purposes. Conservation and directed use of herbaceous plant genefond is performed through the protection of their populations and the existing specimens, collection of their seed material, and their use in landscape management, protection of erosive areas, water, etc. The usage of herbaceous plant species in forest ecosystems is multiple, first of all these plant species participated in the soil erosion control, formation of ground covers, soil enrichment, they participated in decomposition of forest leaves. Some herbaceous plant species are extremely rare which should be protected on special way. Among them there are medicinal herbs and ornamental plant species which represent the potential material for the landscaping of non-forest (open) spaces - pastures and meadow's in the national park. These plant species are great potential for the programs of sustainable development of ecosystems in the National Park "TARA".*

Key words: herbaceous plants, wild flowering plants, medicinal herbs, natural ecosystems, National Park "TARA"

1. INTRODUCTION

Herbaceous plants are plants that grow naturally in grasslands, wetlands, meadows, woodland throughout the world (Stavretović, et al. 2006). They give extremely and unique value observing areas, some of them are medicinal and very decorative herbs. Survival of many species utterly depends on humans. The important of herbaceous plant species in forest ecosystems is multiple. They are forming specific micro climate conditions for same small animals, other plants, and insects and fungous, they are food sores, these plant species participated in erosion control, formation of ground covers, and they participated in decomposition of forest leaves. Same plants can enrich a soil with nitrogen.

Today, scientific, forest engineer and landscape engineers are more interested for usage herbaceous plants like material for green spaces and foresting and for erosion control. They become the main material for the programs of sustainable development. The base criterions for usage and protection of herbaceous plants are: Protection of herbaceous plants, to develop superior types of wildflowers throught plant exploration, selections and evaluation, to determinate the cultural methods could be successfully used for establishing wildflowers with minimal costs, and determine harvesting for commercial seed production.

Herbaceous plant species that are rare, threatened, or endangered should not be dug or removed from their native habitat. Conditions for there growth and breading need to be provide on locations were they are present. With collecting their reproduction material (seed, root parts) we can multiply they number, and on that way we can produce enough seed material for trade.

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A cording to Stavretovic, et al. (2006), guidelines in determining whether a wildflower is desirable or not are:

- The plant must not be a noxious weed
- A desirable plant shouldconfine itself to the area where is planted.
- The plant mus have showy vegetative or reproductive strucuries such as stem, leaves, flowers, and fruits
- The plant must be a perennial of it must self seed and reestablish readily if it is an annual seeding or planting
- It shouldn't be allergen species
- The plant must have a good root system for conversing soil
- The plant must associate and persist compatibily with other vegetation such as grasses

Information on the germination and viability of wildflower seed is limited. A laboratory study was conducted to identify the germination problems of species and to determinate haw best to overcome thease problem. Best time for seeding\planting (to sow) herbaceuse plantes is early spring. Same species have seed dormancy and because of that best seeding time for them is in autumn.

Establishing grass vegetacion and wild flowering plants

Forming area of grass, wildflowers and medical plants, require adequate mathod of establishing thouse vegetation. Contents of seed mixture dependes on surround conditions and olso on the way of using that area. This kind of ground covers can be foremed on clasic way with preparing a soil and with standard sow on entire area (Erić, et al. 2003). If we need a short type of ground cover, were will be ofen mowed, we should choos a species that have low stem and leaf. If we wont to form a hight type of ground cover, seed mixture will content a species with decorative flowers. On that way we have very decorative lawns, maedows and pastures, but olso we expend areal and number of sensitive and endangered herbaceous plants individuals. Medical plants can be used to form specific open space – medical meadows (Panjković, et al. 2000).

Other way of, protection and multiplying number endangered and rare herbaceous plants, is to plant and reseeding on the lokacion from where there vanished. If we do sowing, grass needs to be mowed on hight of 2-3 cm. If the used species of grass don't have hight production of seed, we can not vršiti klasičnu setvu omaškom, it needs to sow on prepared place in there natural ecosystem. In areas were we wont to incrise a fond of endangered and rare herbaceous species, same times we need to fence them to the day when there number will be stabilize, like in case with species *Nepeta rtanjensis* Diklić & Milojević, on mountin Rtanj in Serbia (Mijović et al. 2004).

Aftere incrising the number of endangered and rare herbaceous plants individuals, there protection demande several diferent methods. It needs to be controled there destroing (stepping on them , burning the meadows, cattle breeding) and colecting (medical plants, tea plants).

Incrising the number of plant individuals is not the end of protection a endangered and rare herbaceous plants. Number of herbaceous plants individuals and there health status has to be ofen controled.

The rare herbaceuose species in National Park "TARA" ecosystems

The National Park "TARA" is shelter for great number of rare and endangered herbaceous plants. They are natural wealth of Balkans peninsula and Serbia state, and because of that they need to have special treatment.

The present scientific knowledge gives us opportunity that with breeding and collecting their reproduction material (seed, root parts, parts of trunk) multiplies they number. With resettling their primary areas – inhabitants we preserve rare natural ecosystem types and plant communities, gene fond of rare and endangered herbaceous species. This is the first steps for there survival. If we want a long-time solution we need to find their purpose and commercialisation. Like utilise species witch are decorative, medical and ornamental plant EST.

The species in tables are protected by law in Serbia state lake natural rarity and endangered species. Many of them (*Iris sibirica, Dactylorhiza cordigera, Lilium martagon, Paeonia corallina*) can be used in landscape architecture for: forming hight and low flower medow, forming flower decorative lowns, ground covers, room plants.

Table 1. Herbaceous plants, Natural rarity of mountain Tara

Natural rarity			
Family	Genus	Species	Where they are spread
Asteraceae	Senecio	Senecio umbrosus Waldst Kit.	Kruščica,Biljeg,
Gentianaceae	Gentiana	Gentiana lutea L.	Ljuto polje
Iridaceae	Iris	Iris sibirica L.	Livade oko Jarevca
Iridaceae	Gladiolus	Gladiolus imbricatus L.	Kaluđerske bare,Predov krst
Liliaceae	Lilium	Lilium martagon L.	Crni vrh, Kanjon Drine, Zvijezda
Orchediaceae	Dactylorhiza	Dactylorhiza cordigera(Fries)Soo.	Crni Vrh
Orcheidaceae	Ophrys	Ophrys cornuta Steren	Kanjon Dervente,
Orcheidaceae	Orchis	Orchis laxiflora Lam.	Kaludje.bare
Orcheidaceae	Listera	Listera cordata(L.)R.Br.	Zmajevački potok
Orcheidaceae	Godyera	Godyera repens R.Br	Crvene stene
Orcheidaceae	Epipactis	Epipactis palustris(L.)Crantz	Predov Krst
Paeoniaceae	Paeonia	Paeonia corallina Retz.	Božurna, Zvezda (odelj.)
Sinopteridae	Cheilanthes	Cheilanthes marantae	Serpentini

Table 2. Wanished and endanger herbaceous species in Tara a cording to The Red Book of Serbia

The Red Book of Serbia				
Family	Species	Tara	Endanger in Serbia	ERL
Campanulaceae	Adenophora lilifolia (L)Besser	Gorge Dervente,Podrinje	CRSrb,VU	+
Cyperaceae	Cladium maiscus (L.)Pohl subsp.mariscus	Peat bog Batuski Rzav, Ornice	CRSrb B2c	
Rosaceae	Waldsteinia trifolia	Forests of spruce and omorica (Zaovine)	EX SCG DD	

2. CONCLUSION

Protection, conservation and directed use herbaceous species gene fond, should be done regularly. C ontrol an d p rotection o f there p opulations, wi th co llecting an d pro ducing there reproduction material, should be done also. Ornamental decorative meadows, which are used in landscape management, can be formed with same wildflowers: *Ajuga reptans L., Thym us serpyllum L., Vi ola silvestris Lam.*, and same natural rarity of National Park "TARA", for exempel: *Iris sibirica, D actylorhiza c ordigera, L ilium m artagon, P aeonia c orallina*. L arge n umber o f medical herb s pecies ca n b e s owed, b reeded a nd ex ploated f rom medical me adows in N atoinal P ark "TARA", because medical herbs demand area with out any cound of polutation.

The great economical potential and scientifically significance herbaceous plant species, that are present in Natoinal Park "TARA", should be exploited and directed used in areal plan of management and land use in National Park "TARA". It should be given a special attention to survival and sustainable development of endangered and rare herbaceous plants, witch are natural wealth of Balkans peninsula and Serbia state.

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BIOINDICATORS OF TRUFFLE SITES IN FOREST COMMUNITIES

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Abstract: *Forestry research using the methodology of the presence of bioindicators of truffle natural sites is becoming increasingly topical. Some species react by avoidance, i.e. by the absence from the zone of truffle ecological influence (limitation factor), and others are attracted by the truffle presence at the site (existence factors). In the autochthonous flora, there are significant indicators starting from truffle symbionts with which they are interdependent, to the plant species which avoid them completely or partly. Among animal species, some are attracted by truffles and are used for truffle detection, but there are also animals which avoid them. Many forest tree species in Serbia (pine, birch, oak, lime, sweet chestnut, ash, etc.), by their ecological and biological characteristics, point to the presence of truffles.*

Key words: truffles, bioindicators, ecological indices, site

1. INTRODUCTION

Phytodetection of forest communities is based on the plant ability to indicate the ecological conditions of forest sites, as well as the changes caused by the effect of different external factors. In a sense, plants are more complex indicators of forest sites than the instruments, because of their prompt reaction to different effects which cause deeper, biochemical, physiological, anatomic, morphological, ecological, and other changes.

The founder of bioindication ecology was Linnae (1751), who in the capital *Philosophia Botanica* selected several indicator groups. The term bioindicator was introduced by Clements (1920), to signify the organisms which, by their presence, clearly indicate the ecological characteristics of the site (bios - life, indicare – to point). Site conditions, as well as the presence of the living beings which are otherwise invisible because they are in the ground, such as truffles, can be identified by bioindicators.

2. MATERIAL AND METHOD

The method applied in the research of potential sites is the presence of bioindicators of the truffle natural sites. Some species react by avoidance, i.e. by the absence from the zone of truffle ecological influence (limitation factors), and others are attracted by the truffle presence at the site (existence factors). There are some significant truffle indicators in the autochthonous flora, starting from their symbionts with which they are related, to the plant species which avoid them completely or partially (Kojić *et al.* 1994; Matović *et al.* 1994, 1995; Matović 1993, 1995, 1996; Ratknić *et al.*, 1999a). This paper points to forest woody species which are of the highest

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significance as truffle indicators and proposes the host species suitable for the establishment of artificial truffle plantations.

3. RESULTS AND DISCUSSION

The presence or absence of forest species which are truffle indicators is decided by the prevailing ecological conditions. Their presence is decided by the existence factors, and their absence, by the limitation factors. This research deals predominantly with forest species which are the most frequent indicators of truffle presence in the forests in Serbia (Lindtner 1935; Šilić 1973; Stevanović 1992; Ratknić *et al.* 1999b).

1. COMMON OAK (*Quercus robur* L.) forms lowland forests on deep and fresh terrains. It is the best symbiont of white truffles in our conditions, and it is also often in symbiosis with black truffles. The most significant factors of their presence - existence factors, are deep, clay or sandy, fertile, predominantly moist soils, with a high level of subterranean water. The factors of their absence i.e. limitation factors, are shallow and dry soils. The common oak ecological indices are: moisture (V) - 3, soil acidity (K) - 3, nitrogen quantity in the soil (N) - 3, light (S) - 3, temperature (T) - 4. Based on the above ecological indices, truffles, particularly the white truffle (*Tuber magnatum*), should be expected near their best symbiont - common oak with other submesophytic plants (plants which prefer mesophilic sites, but can also be found in xerophilic plant communities). As for the soil acidity, they are neutrophilic plants which are always found on neutral to weak acid soil. The nitrogen percentage in the soil indicates mesotrophic plants living in the soil medium rich in mineral substances. The light index is indicative of hemisciophytes (plants which cannot survive in the conditions below 10% of full daylight). The temperature indicates the group between mesothermic and thermophilic plants.

2. SESSILE OAK (*Quercus petraea* L.) grows on somewhat higher terrains (Fig.1). It is a good symbiont of both white and black truffles. The ecological factors of its existence which can indicate the truffle presence are fresh acid and podzolic soil, of lowland and hilly terrains. The ecological indices applied in the detection of truffles on the sessile oak sites are: moisture (V) - 2, soil acidity (K) - 3, ntrogen quantity in the soil (N) - 2, light (S) - 3, temperature (T) – 3.The values of these indices show that the optimal sessile oak site, and also of its symbionts truffles, is the site with subxerophytes (plants found both in extremely arid and in mesophilic plant communities). As for soil acidity, they are the sites with neutrophilic plants, which are always on neutral to weak acid soil. Regarding nitrogen quantity in the soil, the sites are the transition between oligotrophic and mesotrophic plants. The presence of truffles is indicated by hemisciophyte plants, and the temperature on these sites is optimal for mesothermic plants.

3. TURKEY OAK (*Quercus cerris* L.) forms the communities on hilly and submontane areas. On its typical warm south sites, it is often in symbiosis with black truffles. Ecological characteristics of its sites are limestone or siliceous bedrock with predominantly deeper weak acid soil. Ecological indices of Turkey oak are: moisture (V) - 2, soil acidity (K) -3, nitrogen quantity in soil (N) - 2, light (S) - 4, temperature (T) - 5. Typical Turkey oak sites on which its symbionts can be truffles are characterised by subxerophytic plants on neutral to weak acid soils. Nitrogen requirements indicate the transition group between oligotrophic and mesotrophic plants. The light as ecological factor indicates the transition group between hemisciophytes and heliophytes, and the temperature conditions suit the thermophilic plants.

4. PUBESCENT OAK (*Quercus pubescens* Willd.) grows mainly in mixed oak forests (Fig.2). It is very important because it is an excellent symbiont of almost all truffles species. The most significant factors which affect their presence - existence factors, are the dry and shallow skeletoid soils on the warmer exposures. Ecological indices of pubescent oak which indicate the

typical sites on which truffles can occur as the symbionts are: moisture (V) - 2, soil acidity (K) - 4, nitrogen quantity in soil (N) - 2, light (S) - 3, temperature (T) - 5. These indices show that the typical sites of pubescent oak and its symbionts - truffles are indicated by the presence of plants which occur both in extremely arid, and in mesophilic communities. Soil reaction supports the transition forms between neutrophilic and basophilic plants. As for nitrogen quantity in the soil, it is the ecological group between oligotrophic and mesotrophic plants. The presence of truffles is indicated by hemisciophytes which cannot survive in the conditions below 10% of full daylight, and the temperature suits the thermophilic species.

5. HAZEL (*Corylus avellana* L.) is widespread in Serbia. It lives in symbiosis with white and black truffles. Because of fast growth, dense and shallow root system, it is widely applied throughout the world in truffle cultivation. The most significant factors of its presence are fresh, fertile and deep soils. Ecological indices of the optimal sites for hazel are: moisture (V) - 3, soil acidity (K) - 3, nitrogen quantity in soil (N) - 3, light (S) - 3, temperature (T) - 3. The indicator values for moisture represents submesophytes, soil acidity - neutrophilic plants, nitrogen quantity in soil - mesotrophic plants, light - hemisciophytes, and temperature -mesothermic plants. As the above data are the medium values of ecological conditions, this gives hazel the advantage compared to other species in the process of establishment of artificial truffle plantations.

6. BLACK POPLAR (*Populus nigra* L.) is in Serbia represented in lowland and lower submontane areas and it is a good symbiont with black truffles and white truffles. The most significant factors of its typical sites are alluvial sandy soils, which are exposed to permanent flooding. Indicator values of black poplar which characterise its typical sites are the following: moisture (V) - 4, soil acidity (K) - 4, nitrogen quantity in soil (N) - 4, light (S) - 3, temperature (T) - 4. The above values show that the indicators of the optimal black poplar sites are: moisture - mesophyte plants, soil acidity – the group between neutrophilic and basophilic plants, nitrogen quantity in the soil - group between mesotrophic and eutrophic plants, light - hemisciophyte plants, and temperature – group between mesothermic and thermophilic plants.

7. WHITE POPLAR (*Populus alba* L.) is a good symbiont with white and black truffles. It does not have great demands regarding soil quality, but it grows best on fresh and rich soils. In Serbia, it occurs frequently on moist terrains along the rivers, mostly in lowland forests. Ecological indices of white poplars, which are the most important in its indication ecology are: moisture (V) - 3, soil acidity (K) - 4, nitrogen quantity in the soil (N) - 3, light (S) - 4, temperature (T) - 5. The data show that such sites are optimal for submesophyte plants which demand soil acidity between neutrophilic and basophilic plants. Nitrogen quantity in the soil is optimal for mesotrophic plants which occur on the soil medium rich in mineral substances. As to light, it is the group between hemisciophytes and heliophytes, and the temperature suits the thermophilic plants.

8. ASPEN (*Populus tremula* L.) occurs individually or in smaller groups in oak, beech, spruce and other forests, where at the optimal sites it lives in symbiosis with black truffles and white truffles. It occurs from the lowlands on alluvial soils, to skeletal soils of the montane zone. Its ecological indices are: moisture (V) - 3, soil acidity (K) - 3, nitrogen quantity in soil (N) - 3, light (S) - 4 and temperature (T) - 3. This indicates that its optimal site is characterised by submesophytes. The soil reaction indicates the neutrophilic plants, as to nitrogen quantity - mesotrophic plants, light – plant group between hemisciophytes and heliophytes and the temperature suits mesothermic plants.

9. WHITE WILLOW (*Salix alba* L.) occurs in the lower landscapes and river valleys. It grows very fast and for a short time produces good-quality white truffles (*Tuber magnatum* Pico ex Vitt.). White willow demands special conditions among which are the most significant factors of its presence - existence factors, such as good alluvial soil, with sufficient moisture and abundant light. Its typical sites are charactreised by the following ecological indices and indicator values:

moisture (V) - 4, soil acidity (K) - 4, nitrogen quantity in soil (N) - 4, light (S) - 3, temperature (T) - 3. This means that the sites support the ecological group of mesophytes. The soil acidity supports the ecological group between neutrophilic and basophilic plants, as to nitrogen presence - ecological group between mesotrophic and eutrophic plants, as to light – hemisciophytes, and as to temperature mesothermic plants.

10. BRITTLE WILLOW (*Salix fragilis* L) occurs at the similar sites as the white willow and lives in symbiosis with white truffles. Its typical site and community are characterised by the following ecological indices: moisture (V) - 4, soil acidity (K) - 3, nitrogen quantity in soil (N) - 3, light (S) - 3 and temperature (T) - 3. It differs from white willow only by soil nitrogen demands, therefore the mesotrophic plants are dominant on its typical site.

11. SALLOW (*Salix caprea* L.) is a good symbiont with truffles. It occurs individually or in smaller groups in different forests. Among the ecological factors which characterise its optimal site are the fertile and moist soils. A more complete idea of its optimal site is provided by its ecological indices: moisture (V) – 3, and soil acidity (K) - 3. This means that these sites are inhabited by submesophytes, and the soil reaction is optimal for the ecological group of neutrophilic plants.

12. LARGE-LEAVED LIME (*Tilia platyphyllos* Scop.) mostly grows in the hilly region in Serbia, where it is in the composition of numerous mesophilic forests. It is a very good symbiont of white and black truffles. Its site conditions include special demands of nutritive, mild humus soils with sufficient air humidity. Its optimal life conditions are shown by the values of its ecological indices: moisture (V) - 3, soil acidity (K) - 3, nitrogen quantity in soil (N) - 3, light (S) - 2, temperature (T) - 4.

13. WHITE LIME (*Tilia tomentosa* Mnch.) has similar distribution as the large-leaved lime, it lives in symbiosis with white and black truffles. The specific sites conditions are indicated by the following ecological indices: moisture (V) - 3 which indicates the presence of submesophytes, soil acidity (K) - 4 which indicates the group between mesotrophic and eutrophic plants, nitrogen quantity in soil (N) - 2 which indicates the presence of the group between oligotrophic and mesotrophic plants, light (S) - 4 which indicates the group between hemisciophytes and heliophytes, temperature (T) - 4 which indicates the group between mesothermic and thermophilic plants.

14. BEECH (*Fagus silvatica* L.) occurs on different geological bedrocks and soil types. It is a good symbiont of most black truffles (*Tuber melanosporum* Vett., *Tuber aestivum* Vitt., *Tuber brumale* Vitt.). The ecological indices of beech optimal sites are: moisture (V) - 3 which points to the presence of submesophyte plants, soil acidity (K) - 3 which points to neutrophilic plants, nitrogen quantity in the soil (N) - 3 which represents mesotrophic plants, light (S) - index 2 which represents the group between sciophytes and hemisciophytes and temperature (T) with indicator value 3, which represents mesothermic plants.

15. SWEET CHESTNUT (*Castanea sativa* Mill.) is a symbiont of most truffles. Its optimal sites are on fertile, deep, loose and moderately moist soils. The ecological characteristics of sweet chestnut sites are best represented by the numerical parameters of the indicator values: moisture (V) - 3 which points to the domination of mesophytes, ecological index of soil acidity (K) is 2 and it shows that sweet chestnut belongs to the group between acidophilic and neutrophilic plants, nitrogen quantity in soil (N) - 2 shows that this species belongs to the group between oligotrophic and mesotrophic plants, light (S) indicator value is 3 and it represents hemisciophytes. Temperature (T) indicator value is 4 and it represents the group between mesothermic and thermophilic plants.

16. AUSTRIAN PINE (*Pinus nigra* Arn.), as well as our other pine species, is an excellent symbiont of most truffles. It has a high mycorrhisation capacity and transfers mycorrhiza to other tree species. The optimal sites for Austrian pine are xerothermic sites, predominantly on limestone, dolomite and serpentine, mostly on the warmer exposures of the submontane belt. As

all the ecological groups of plants (1 to 5) are explained in the above descriptions, we shall present only the numerical indicator values of key ecological factors which characterise the Austrian pine optimal sites: moisture (V) - 2, soil acidity (K) - 4, nitrogen quantity in soil (K) - 2, light (S) - 4, temperature (T) - 4.

17. SCOTS PINE (*Pinus silvestris* L.) lives in symbiosis with most white truffles and black truffles. Its optimal sites are on sandy and stony, dry, deep and mineral-rich soils. Ecological indices of Scots pine are: moisture (V) - 3, soil acidity (K) - 3, nitrogen quantity in soil (N) - 2, light (S) - 4, temperature (T) - 3. The presence of black truffles can indicate the absence of herbaceous plants in the mycorrhiza zone. The visible openings caused by black truffles occur during summer and autumn, when mycelium growth in the soil is the most intensive and when black truffles are ripening. If the area in mycorrhiza zone is stony, the stones are clean and smooth, without mosses which grow on the stones. There are several explanations of this phenomenon, the most probable is that black truffle mycelium excretes the antibiotics which disable the function of herbaceous plant roots, causing their death. This indicator, together with truffle fly, is a great advantage in the search of black truffles. However white truffles do not offer any external signs of their presence.

In addition to the above species, there are some more tree and shrub species which indicate the chemical characteristics of the soil in which truffles could succeed. They are: *Crataegus oxycantha* L., *Staphylea pinnata* L, *Cornus mas* L., *Prunus mahaleb* L., *Cotinus coggygria* Scop., *Ostrya carpinifolia* Scop., *Colutea arborescens* L., *Fraxinus ornus* L., *Sorbus aria* (L) Cranz., *Juniperus oxycedrus* L., etc. Some representatives of the forest community ground layer can also be the indicators of truffle presence: *Festuca ovina* L., *Festuca rubra* L., *Hieracium pilosella* L., *Allyssum saxatile* L., *Arabis hirsute* (L.) Scop., *Trifolium repens* L. etc. Truffles should not be looked for at the sites of acidophilic tree and shrub species, such as: *Carlina vulgaris* L., *Genista germanica* L., *Genista tinctoria* L., *Pteridium aquilinum* (L.) Khn., *Digitalis purpurea* L., etc.

In addition to phytoindicators, numerous zoo-indicators are also used, e.g. truffle fly, red-brown snail, etc.

Fig. 1. Quercus petraea L.

Fig. 2.Quercus pubescens Willd.

4. CONCLUSIONS

Of all forest species in Serbia, which live in symbiosis with truffles, oaks are the most numerous per species, they have the widest distribution and they are the best symbionts of truffles, because they produce good-quality truffles and have a multiannual productive capacity. Poplars are, thanks to their fast growth the most favourable species for the establishment of artificial truffle plantations and already after a short time they begin producing truffles for the following 35 to 40 years. Willows and poplars, thanks to fast growth, soon produce a satisfactory quality and quantity on autochthonous sites, and they are economically very interesting for the establishment of artificial truffle plantations. Limes are good symbionts for almost all white and black truffles and they are very favourable for growing truffles in tree rows and parks. All species of our pines are excellent symbionts for most white truffles and black truffles. They are very favourable for the mycorrhization in the autochthonous forest stands because the introduced mycorrhized seedlings soon transfer the mycorrhiza to the surrounding native trees. Bioindicators are applied only for the detection of the localities, and the truffles are detected by different trained animals. In most countries truffles are detected by different species of dogs, in France - trained pigs, and in Russia also trained bears.

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ENDEMORELIC TREE SPECIES IN SOUTHWEST SERBIA

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Abstract: *The world list of the International Union for the Conservation of Nature and Natural Resources (IUCN) contains about 300 plant species from Serbia. However, many of our local endemic woody species have not been listed and among them in Southwest Serbia, the most endangered coniferous species are: Mišić's spruce (Picea abies var. misicii Matović et Pavlović), golden pine (Pinus sylvestris var. zlatiborica Oman.), Vukoman's Serbian spruce (Picea omorika (Panč.) Purkyne var. vukomanii Pavlović et Matović) and pyramidal fir (Abies alba var. pyramidalis Carr.). These selected rare forms of conifers in Southwest Serbia are the evidence of the evolution processes and the priceless value of forest tree gene pool in this region.*

Key words: Mišić's spruce, golden pine, Vukoman's Serbian spruce, pyramidal fir

1. INTRODUCTION

Rich forest ecosystems in Serbia have an exceptionally high significance for the conservation of floristic diversity. The Southwest part of Serbia is one of the centres of floristic diversity, not only for Serbia, but also for the wider area of the Balkan Peninsula. The Southwest Serbia trees and shrubs are unique thanks to the great diversity and abundance of species of international significance (Stevanović and Vasić, 1995, Josifović, 1970-1977). Among them, there is a considerable number of endemic and relic species which give the flora a specific characteristic. In contrast to a great part of Europe, which was covered with ice for hundreds of thousands of years, and the history of plant species started after the ice retreat, the area of Southwest Serbia belongs to the part of the Balkan Peninsula which, thanks to its geomorphologic characteristics (Mišić, 1981, 1982, Cvijić, 1924), had well protected refugial sites in which many plant species could survive the ice age. The specific ecological circumstances in the geological past made the Southwest Serbia a centre of numerous plant species from the Tertiary and later time periods. A great number of endemic plants which, due to geological-historical factors, had the limited distribution to these and some surrounding areas, represent the rare and few residues of the ancient (relic) flora, many of which are more or less endangered, and among them also many woody species: sweet chestnut in the Canyon of the river Mileševka, yew in the river Lim valley and on the slopes of Jadovnik, Turkish hazel in the gorge of Ratajska Reka, white-bark pine on Ozren and Kamena Gora, Balkan maple on Mt. Ozren. The following varieties are particularly endangered and rare: Vukoman's Serbian spruce, Mišić's spruce, pyramidal fir, and golden pine (Rakonjac *et al*., 2005 after Matović et Rakonjac, 2006).

The identified frequency of infraspecific atypical tree and shrub forms of different species, i.e. genera, at a small geographical distance in Southwest Serbia, has not been completely elucidated. The explanation of their occurrence is significant for the understanding of the genetic structure of the population and the evolution process, and also for the devising and implementation of the

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appropriate protection of natural rarities, as well as for their utilisation in taxonomic and genetic researches.

2. METHOD

The rare forms of trees and shrubs were researched on the territory of the Municipalities Prijepolje (the site of Vukoman's Serbian spruce *Picea omorika* /Panč./Purkyne var. *Vukomanii* Pavlović et Matović and Mišić's spruce *Picea abies var. Misicii* Matović et Pavlović), Sjenica (the site of pyramidal fir *Abies alba var. pyramidalis Carr.*) and Nova Varoš (the site of golden pine *Pinus sylvestris var. zlatiborica Oman.)*. These three Municipalities occupy the greatest part of Southwest Serbia. The researches were carried out in the field, in the laboratory conditions and in the greenhouse, as well as based on the literature data (Šilić, 1984; Vidaković, 1982; Jovanović, 1971). The floristic research was performed by the usual Braun-Blanquet's method (Stefanović, 1977). The above four locally endemic tree species in the area of Southwest Serbia are distributed in a very narrow space, often in the area not larger than several ares. Our research synthesises the data on the state of the above rarities of dendroflora in Serbia, their genetic and taxonomic status. On this basis, the concept of their further study, maintenance and propagation is proposed.

3. RESULTS AND DISCUSSION

3.1. Short description of the varieties based on the literature data and their present state

1. VUKOMAN'S SERBIAN SPRUCE. *Picea omorika* /Panč./ Purkyne, is the latest discovered (Matović, 1982, 1983, 1985, 1986, after Matović et Rakonjac, 2006, Dizdarecvić *et al*. 1982, after Matović et Pavlović, 1994, Dizdarecvić *et al*. 1984). It grows in the Canyon of the river Mileševka and it is protected as the natural rarity (Figures 1 and 2). Based on the ecological, morphological, biogeographical and biosystematic characters, it was described as a variety: *P. omorika var. Vukomanii* Pavlović et Matović (Pavlović et Matović, 1994), which differs from the typical species (Purkyne, 1877) based on several characteristics. It also differs from the already described lower systematic units (Vidaković, 1982). This, once more numerous population, was reduced by torrents to altogether about 30 individuals (Matović, 1990a, 1990b, 1992), which occasionally bear seed.

Figure 1. Vukoman's Serbian spruce in the Mileševka Kanyon

Figure 2. Propagation of Vukoman's Serbian spruce

2. MIŠIĆ'S SPRUCE. Several trees of this unusual spruce grow at two localities in the area of Kamena Gora near the road Prijepolje – Pljevlja. They are mixed in the populations with the typical species. The basic data on the phenotype and the site were presented by: Đoković, 1971, Matović, 1988, Matović et Vujković 1994a, 1994b. This spruce was first described as a new, unnamed form of the mutant spruce (Matović, 1988), and then as a new variety, *Picea abies* var. *misicii* Matović et Pavlović, with a more in depth description of its morphological characters (Matović et Pavlović, 1994). It was named in the honour of Dr. Vojislav Mišić, well-known researcher of flora and vegetation in Serbia. This variety, based on its unique habit, morphological characters of the needles and other characteristics, does not correspond to any of the already more than 100 described spruce cultivars and varieties which were described by Krisman 1968, after Vidaković, 1982. The flowering and seed bearing of the above trees have not been observed (Figure 3). The efforts of vegetative propagation of this variety have not been completely successful to date (Figure 4).

Figure 3. Mišić's spruce

Figure 4. Propagation of Mišić's spruce

3. PYRAMIDAL FIR. *Abies alba var. pyramidalis Carr.,* was found on the mountain Ogorijevac near Sjenica (Tošić, 1963, 1995). Its site has been protected by the State since 1965. This unusual and rare fir is represented by a few trees in the numerous silver fir population (Figure 5). After Vidaković, 1982, pyramidal firs are mutant forms, but also the recognised taxa at the level of the variety. The differences between pyramidal fir and silver fir in numerous morphological characteristics were described also by Matović *et al.* 1995. Pyramidal fir was successfully grafted by M. Tošić on the rootstocks of *A. alba* and these individuals have been flowering and seed bearing already for years (Tošić et Nikolić, 2006). A clonal archive of 580 grafts of this variety was established on Golija by the same author, in cooperation with SE "Srbijašume", FE Golija.

Figure 5. Pyramidal fir in population with Silver fir

4. GOLDEN PINE. *Pinus sylvestris var. zlatiborica Oman.* A golden pine tree was found in the village Negbina on Zlatibor. This unique tree was first described by Omanović, 1937. It intrigued the scientific spheres for a long time, so it was protected as the natural rarity before the Second World War. The golden-yellow needles of this rare form are less dense and shorter than the needles of the typical species and they remain for relatively short time on the branchlets (Pavlović *et al.*, 1995). In the last years, the stand of Scots pine with the golden pine was severely degraded, which led to the landslide and tree falling during the winter 2004 (Figure 6). The only tree lost its reproductive function. Fortunately, the geneticist Dr. Mihailo Tošić grafted successfully about 30 Scots pine trees with the golden pine scions (Tošić, 2000), and at the Institute of Forestry, the

attempts of golden pine propagation by rooting method are partially successful. Previous efforts of reproduction by micro-propagation were not successful.

Figure 6. Golden pine before falling

3.2. Analysis of genetic variability of the rare forms and the proposed measures for future study and conservation

The low frequency of the above rare forms of Serbian spruce, spruce, fir, and Scots pine in the populations and their incomplete function in the physiological sense (atypical growth and branching, absence of flowering and fructification, chlorosis, and untimely shedding of golden needles, etc.), indicate that these are the rare or less rare mutant forms of the basic species, which mutated in the specific conditions in some time in the past, e.g. fire (pyramidal fir, Mišić's spruce) or coldness (Vukoman's Serbian spruce and golden pine). By his impact on the ecological factors at the global level or directly by forest cutting, destruction of seedlings, etc., man has certainly more or less contributed to the reduction of the number of individuals of these rare forms. The research of variation of the generative progeny of rare species (if they bear seed) in the stage of early seedling development can help in the potential early identification, selection and multiplication of these and other mutations. This refers particularly to Vukoman's Serbian spruce and pyramidal fir, because they produce progeny, and which, taking unto account the all-age structure of the populations, were probably produced by a small number of individuals (the so-called principle of population founder). Small populations are loaded with genetic variability, so the chances are greater of detecting many rare homozygous mutations in the generative progeny produced by inbreeding. This explains the greater frequency of the rare forms of pyramidal fir varieties in the population on Ogorijevac compared to other natural fir populations. One of the visible mutations, for which it is also supposed to be the consequence of the conversion of heterozygous recessive mutations into the homozygous state, and which is more frequent in small populations, is vivipary, in our region described in *P. heldreichii* Christ. (Tucović et Stilinović, 1975, Tucović,

1987) and *P. wallichiana* (Nikolić, earlier Milojević, 1989). Based on the same principle, there are some indications that the population of Vukoman's Serbian spruce in the Mileševka Canyon is the south branch of its once larger range from the period before the glaciation. The reduction of the number of individuals resulted primarily in the decrease of genetic variability, and then in its sudden increase by gene drift and by the divergence of this population compared to the more Northern part of the range (mountain Tara), which has become visible through the morphological specificities. In the case of *Pinus heldreichii,* the divergence of the populations from Italy and Bulgaria has been genetically confirmed (Morgante *et al.* 1993; Naydenov *et al.* 2005) and it is explained by the fact that it often occurs on the margins of the species range, and that it is the consequence of the gemorphological changes in the ancient past (Bucci *et al.* 1997). For this reason, it is of exceptional significance to study the genetic structure of the rare forms, as well as the populations in which they appeared.

As for golden pine and Mišić's spruce, the conservation of these rare mutations is possible only by vegetative propagation. The field and laboratory researches, performed by the Institute of Forestry in Belgrade for already a long time, in the aim of gene pool conservation of the above four rare forms of conifers (Figure 7) resulted in partially successful vegetative propagation (Pavlović *et al.*, 1995, Matović *et al.*, 2005, Matović and Rakonjac, 2006).

Afforestation can be one of the risk factors in the conservation of the rare forms, because unwise afforestation can cause the change of the population genetic structure, either by improving or by endangering some of its characteristics. The rare forms are usually the first among the endangered ones, so afforestation should be avoided in the areas in which they grow. If afforestation is planned, it should be with autochthonous seed and planting material. At the same time, the study and the protection should not be focused only on the rare individuals, but also on the populations and ecosystems in which the rare individuals appear.

Figure 7. Vegetattive propagation of rare and endemic tree species

4. CONCLUSION

As the unrepeatable part of the gene pool, endemic plants deserve exceptional attention. Endemic plants in Serbia most often have a disjunctive range of distribution and they are mainly represented on limestone, dolomite and serpentine bedrocks, in the rock crevices, on stony lands or screes. They provide specific features to our vegetation in which a great number of endemic communities and higher vegetation units are the reflection of very diverse climate, petrographic-edaphic and orographic conditions. The richness and diversity of endemic plants in our flora point to the continuity of the favourable life conditions. They are an exceptionally significant object of scientific research, and simultaneously they are also an important document for the history of the vegetation cover in Serbia. Many endemic plants are endangered by modern man. Therefore, measures of their urgent protected should be undertaken and they should be extended to their original sites, aiming at the conservation of our flora diversity and beauty. This problem is of national interest and it can be solved by persistent work on the education of both school children and adults, and this paper has also been devoted to this aim.

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INTRODUCTION OF NON-INDIGENOUS SPECIES AND BIOSECURITY

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Abstract: *The introduction of non-indigenous species to the new areas is mainly performed for two reasons: aesthetical and economic. Only those species are selected that have a greater, or at least the same, value as the native tree species. The raising of exotic species for forestry purposes, in the plantations on the sites in Europe started two centuries ago, and the establishment of forest plantations in West and Central Europe has more than a hundred years long tradition. By the correct selection of introduced species, forestry can reclaim the degraded sites and increase the felling volume on the good sites. The achievement of the economic and general ecological effects of the exotic species introduction to Serbia requires the permanent analyses, and a part of the results is presented in this paper. The objectives of this study are as follows:*

- By the study of the interaction of the exotic species genetic potential and the ecological conditions of the environment to which they are introduced, to contribute to the correct selection of tending and protection measures, necessary for the sustainable development of the cultural communities of exotic species;

- By the research of production and adaptation potentials of the exotic species cultivated in Serbia, identify the economic and ecological justification of further introduction planning and implementation.

Key words: Introduction, biosecurity, exotic species, provenance, selection

1. INTRODUCTION

Introduced species are represented in the terminology by numerous terms: allochthonous, acclimatised, bioinvasive, foreign, adventive, wild, naturalised, immigrant, non-indigenous and xenobiotic. The distance between these terms can be and should be made. The most widely used term is – introduced species, as the synonym for non-indigenous species of plants and animals.

According to the definition, a species is considered as "introduced" when it is translocated outside its natural range by human impact. The ecological puritans like to argue that introduced species are never capable of adapting completely to the new conditions. According to the definition of the Agency for Environmental Protection of the United States, in which perhaps the ecological refinement is absent: the "introduced species are the species which can become capable of surviving and reproducing outside their natural site, at the site where they will develop successfully and spread."

Most often, the motivation for the species introduction to the new sites is the economic interest.

The demands of wood industry promoted the introduction of *Pinus radiata* from California to Australia and New Zealand. This economic example confirms the fact that the introduced species has become one of the major commercial species in these countries and that it satisfies

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the needs of both wood industry and forestry. The economic reasons are not the only reasons of introduction, the ornamental quality of the species is also significant, as well as erosion control, meeting the needs of fodder production, biological control of invasive species and the suppression of natural enemies.

Introduction or translocation is significant also for the genetic conservation which represents the introduction of new individuals in genetically depleted populations of the threatened plant or animal species.

In any case, the introduced species enrich the biodiversity of the region.

2. MATERIAL AND METHOD

Numerous factors influence the success of forest tree afforestation and it is necessary to take into account the significance of the selection of the genetic material.

The selection of species for afforestation is a crucial moment in the aim of avoiding many decades of errors which each forestry expert should foresee in advance. The correct selection of suitable species is based on the correct selection of the provenances. The process of priority selection of species will be solved with a compromise by the introduction of allochthonous species, in the cases where they will be more suitable by their quality than the autochthonous species. Allochthonous species are successfully applied in monocultures, for more than 40 years the material for afforestation in forestry has been focused on a small number of introduced species. By the correct use of introduced species, forestry can rehabilitate the degraded sites and increase the felling volume on the better sites.

The introduction is justified for the following reasons:

- gene pool enrichment of the local flora,
- increase of resistance to diseases and unfavourable site conditions,
- increase of volume increment,
- ensure the selected planting material,
- ensure the better quality of wood and
- greater wealth of ornamental properties of the species.

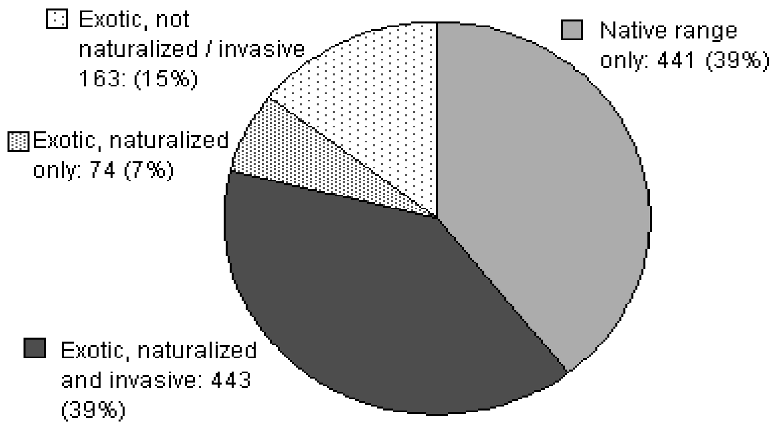
The introduced species or provenances can have a positive effect also on natural vegetation through the formation of hybrids with the local, well adapted species and provenances.

The Institute of Forestry has established several provenance tests on many localities in Serbia in the aim of testing the adaptation and the genetic potential of the introduced species, Douglas-fir (*Pseudotsuga menziesii* /Mirb/Franco). On Mt. Juhor and in Tanda near Bor, the provenance experiments were established in 1982 with 29 different provenances originating from the part of their natural range in North America. In the Faculty of Forestry arboretum in Belgrade, a provenance experiment was established in 1999 with 14 different provenances of Douglas-fir originating from Canada.

After long-term research, the results show that the provenances from the States Oregon and Washington have excelled by numerous properties, as productive provenances, with a high degree of adaptation.

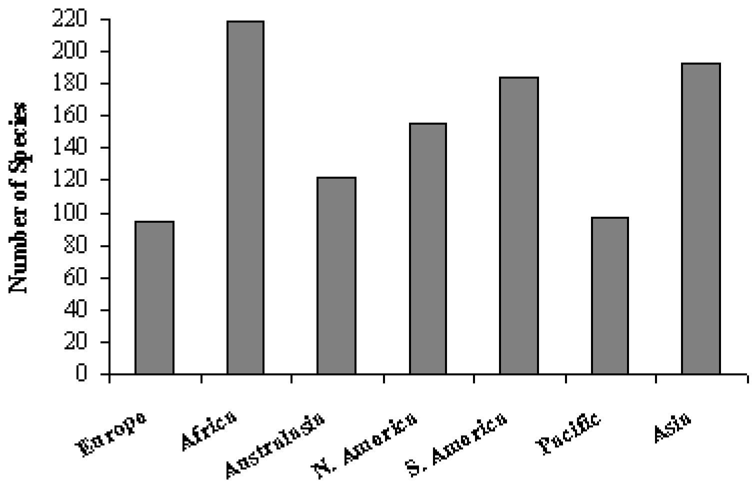
Pursuant to FAO data, it is known that 1121 tree and shrubs species can be found outside their native range (1026 species of broadleaves and 95 species of conifers). Figure 1 presents the geographic distribution i.e. behaviour and status of forest tree and shrub species. Only 39 % of species are in their native range, 7 % are naturalised exotic species, 15 % are not naturalised/invasive species and 39 % are exotic, naturalised and invasive species. Among the introduced species, the most numerous are in the families *Leguminosae, Pinaceae, Myrtaceae, Rosaceae, Cupressaceae, Meliaceae, Salicaceae, Palmae, Fagaceae* and *Moraceae*.

Figure 1. A summary of the distribution of the 1121 trees in the dataset according to geographical distribution and invasion behaviour



It is known (based on the data of the World Agroforestry Centre, 2002 and FAO 1999) that 388 of 458 forest tree species (85 %) are outside their native range and have been introduced to the seven geographic regions: Europe, Africa, Australia, North and South America, Pacific and Asia. It is presented in Figure 2.

Figure 2. Number of forestry species that were recorded as having been introduced into each of seven geographic regions.



2.1 Introduction risk

The introduction of allochthonous species includes a risk. Allochthonous species can have a negative effect on the native plant and animal communities. Some exotic species can be aggressive and, by invasion, they can soon replace the indigenous species and change the native site, because they do not have any natural pests in the new conditions. The dramatic effect on plant community, after the invasion of allochthonous species, can be prevented by maintaining the balance between the original indigenous species and the introduced species.

2.2. Management of biosecurity problems

Forestry profession can make a significant contribution in the process of control of the introduction of foreign species in several ways, including the transfer of forest reproduction material, increase of wood volume, packing material, roundwood trade.

The greatest risk is that the introduced species becomes an invasive species and in this way threaten the economic value of the ecosystem and the quality of the life cycle.

3. CONCLUSIONS

The following conclusions can be made:

- Both the positive and the negative characteristics of the introduction of allochthonous species should be analysed, i. e. the conflicting economic-ecological-social interests should be harmonised;
- The biological attributes (qualities) such as life history, taxonomic status and genetic constitution of the species, in combination with ecological factors, are the main indicators of the introduction;
- The motives for the species translocation are: "cultural and emotive nostalgia" caused by the migration of the population, biological control of the agents, genetic conservation of the depleted populations and threatened species, the aesthetic motive, and the most frequent motive of introduction is the economic reason;
- The concept of introduction of allochthonous species should be under strict control, to prevent the change of the ecosystem function;
- The balance between indigenous and introduced species should be found;
- The introduced species should be tested by the method of provenance tests, to avoid the danger of transfer of unproductive provenances;
- In the aim of economic justification, the selection of introduced species should meet the demands of both forestry and wood industry;
- Introduced species should, in addition to economic justification, meet both ecological and social purposes of the introduction;
- The introduction of new genotypes can potentially cause the negative effects through the movement of the indigenous taxa or genotypes, or it can cause the gene transfer to the local population, with the potential development of unusual ecological characteristics.

The introduction of non-indigenous plants, animals and pathogens is one of the essential global ecological challenges and one of the major causes of biodiversity loss and the changes in all ecosystems of the world (Mooney and Hobbs, 2000).

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ACER HELDREICHII OPRH. IN SOUTHWEST SERBIA

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Abstract: *Acer heldreichii, Oprh. is represented in the flora of Southwest Serbia. The floristic composition of the community with Balkan maple indicates the progradation phase on the site of beech, fir and spruce. Balkan maple, which was represented in the previous community, now under the reduced competition and in favourable ecological conditions, is spreading and it has taken the role of the edificator of the stands in the process of vegetation renewal.*

Key words: *Acer heldreichii* Oprh., Southwest Serbia, fir, beech, spruce

1. INTRODUCTION

Balkan maple (*Acer Heldreichii* Oprh.) is an endemic of the Balkan Peninsula; it grows in Greece, Albania, the former Yugoslavia and Bulgaria, mainly at the altitudes between 1200–1800 m. It is in the Red Data List, and by the categories of species at risk of the International Union for the Conservation of Nature (IUCN), it belongs to the vulnerable species (V).

It grows in different communities, above the belt of beech with fir, in the belt of white-bark pine, spruce, beech, fir and spruce, or submontane beech. On the Pešter Plateau, it occurs in the form of several solitary trees in the vicinity of the settlement Blato, northeast of the village Dunišić, at the site called Beli Kamen. Also it was found, together with beech and aspen, on the north exposure of Crni Vrh (1250 m), on Mačkovac above Jasikovac (several groups of smaller Balkan maple and spruce trees), as well as at the locality Krlje, in the community with beech, spruce and sycamore maple.

2. RESULTS

In the area of southwest Serbia, there is a stand of Balkan maple *Aceri heldreichii-Piceetum abietis* Mišić et Panić, 1990 (CODE 040303.4-05) at the site Litica on the peak of the mountain Ozren (1494 m asl.). The community occupies the north exposure in a narrow belt on the siliceous bedrock, which is inserted between limestone massifs of Jadovnik and Ozren which consists entirely of serpentine.

In the Palaearctic site classification, the introduction of a NEW SITE WITH A NEW CODE has been proposed: ILLYRIAN *ACER HELDREICHII* - SPRUCE FORESTS – CODE 42.25421

The community occurs at the north and northwest exposures, at the altitude of 1400m and slope 10° to 25°. It is well protected against dry and cold winds which blow from the Pešter Plateau. The warm and humid air masses which come from the Lim valley are the decisive factors of the survival of the fragments of this community. Bedrock consists of diabase-hornfels formation, and the soil is eutric cambisol.

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In the tree layer, the dominant tree is *Acer heldreichii*. Spruce (*Picea abies*) and beech (*Fagus moesiaca*) are less represented. *Sorbus aucuparia, Salix capreae, Sorbus austriaca, Betula pendula* are also represented in the upper layer. In the shrub layer, in addition to Balkan maple and beech (*Fagus moesiaca*), there are also *Picea abies, Corylus avellana, Juniperus communis, Populus tremula, Ribes grosularia, Sorbus aucuparia* etc. In the ground flora layer, the most represented species are *Pancicia serbica, Melampyrum nemorosum, Pulmonaria officinalis, Galium silvaticum, Asperula odorata, Viola silvestris, Deschampia flexuosa, Veronica officinalis, Alchemila vulgaris, Astrantia major, Lamiastrum galeobdolon, Dentaria bulbifera, Paris quadrifolia,* etc.

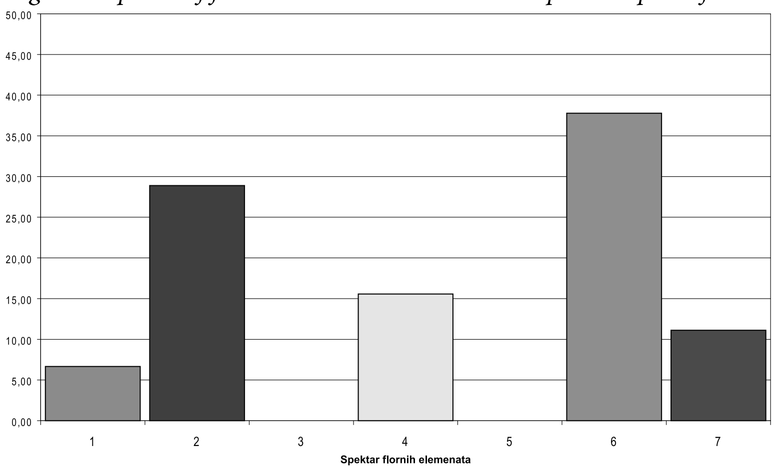
Floristic composition of the community in the forests of Balkan maple and spruce:

Acer heldreichii Orph.	*Melampyrum nemorosa L.*
Alchemila vulgaris L.	*Pancicia serbica*
Anemone nemorosa L.	*Paris quadrifolia L.*
Aremonia agrimonoides (L.) DC	*Picea abies Kars.*
Armeria alpina (DC) Willd.	*Plantago altissima L.*
Asperula odorata L.	*Populus tremula L.*
Astrantia major L.	*Potentila erecta (L.) Raucsh.*
Betula pendula Roth.	*Pulmonaria officinalis L.*
Brachypodium silvaticum (Huds.) P.B.	*Ranunculus serbicus Vis.*
Briza media L.	*Ribes grossularia L.*
Campanula sphaerotrix	*Ribes petraeum Wulf.*
Cardamine bulbifera L.	*Rubus idaeus L.*
Chaerophyllum aromaticum L.	*Rumex arifolius All.*
Corylus avelanna L.	*Salix capreae L.*
Dactylis glomerata L.	*Sanicula europaea L.*
Deschampsia flexuosa (L.) Tr.	*Scrophularia nodosa L.*
Fagus silvatica L.	*Silene vulgaris (Mnch.) Gar.*
Festuca pratensis Huds.	*Sorbus aucuparia L.*
Fragaria vesca L.	*Sorbus austriacus (Beck.) Hedl.*
Galium silvaticum L.	*Stachys serbica Panč.*
Helleborus odorus W.et K.	*Trifolium pratense L.*
Juniperus communis L.	*Veronica officinalis L.*
Lamium galeobdolon (L.) Nath.	*Viola silvestris Lam.*
Lilium martagon L.	

The community is a progradation phase occurring at the site of beech, fir and spruce. Balkan maple, which was represented in the previous community, in the conditions of lower competition and favourable ecological conditions, widened its range and took over the role of an edificator of the stands in the phase of successive changes. *Pancicia serbica,* together with other mesophilic species, penetrated from the adjacent meadows into the thinned forest, and it became dominant in the ground flora layer. Its presence and dominance in the community is the secondary phenomenon related to the degradation of the beech, fir and spruce forest. The floristic composition is typical for the forest of beech, fir and spruce, so this is not a relic community (Matović, 1993).

In the community of Balkan maple and spruce, the highest percentage is that of hemicryptophytes (51.06%). The percentage of phanerophytes is 27.66% (21.28% phanerophytes and 6.38% nanophanerophytes), geophytes 14.89%, herbaceous chamaephytes 4.26% and terrophytes 2.13%. The community is a hemi-cryptophyte-phanerophyte type.

Figure 1. Spectre of floral elements in the Balkan maple and spruce forests



Legend of the spectre of floral elements: 1- Arctic and Boreal, 2- Central European and European, 3- Sub Atlantic and Atlantic, 4- Sub-Mediterranean and Mediterranean, 5- Pontic-central Asian, 6- Eurasian; 7- Circumpolar and Cosmopolitan

The spectre of floral elements is characterised by the dominance of Eurasian (37.78%) and central European floral elements (26.67%). The percentage of Sub-Mediterranean elements is 15.56%, Circumpolar 11.11%, and Arctic and Boreal 6.67%. The Pontic-central Asian floral elements are not recorded in the community.

Table 1. Spectre of floral elements in the forests of Balkan maple and spruce

Group of floral elements	Floral element	Percentage	
1. Floral elements of the north			
Arctic floral elements			
Boreal floral elements	Sub boreal	2.22	
	Sub boreal-Circumpolar	2.22	
	Boreal-Eurasian	2.22	0.67
2. Central European floral elements			
Central European	Central European	11.11	
and European	Subcentral European	11.11	
	Sub central Russian	2.22	
	Alpine-Carpathian	2.22	6.67
3. Sub Atlantic floral elements			
Sub Atlantic and Atlantic	Euroafrican	2.22	20.22
4. Sub-Mediterranean floral elements			
Sub-Mediterranean	Sub-Mediterranean	2.22	
East sub-Mediterranean	East sub-Mediterranean	4.44	
Balkan and	Moesian	2.22	
Balkan-Apennine	Sub-Illyrian	2.22	
	Central Balkan	2.22	
	Central Balkan-south Apennine	2.22	5.56
5. EURASIAN floral elements			
	Sub south Siberian 4	.44	
	Eurasian	17.78	
	Sub-Eurasian	15.56	7.78
6. Circumpolar and cosmopolitan floral elements			
	Circumpolar	11.11	1.11

The average values of ecological indices of the Balkan maple and spruce forest are the following:

- for moisture 2.89 (2.77 - 2.94);
- for chemical reaction soil 3.05 (2.95 - 3.16);
- for nutrients 2.80 (2.68 - 2.90);
- for light 2.48 (2.34 - 2.58);
- for temperature 2.81 (2.65 - 2.92).

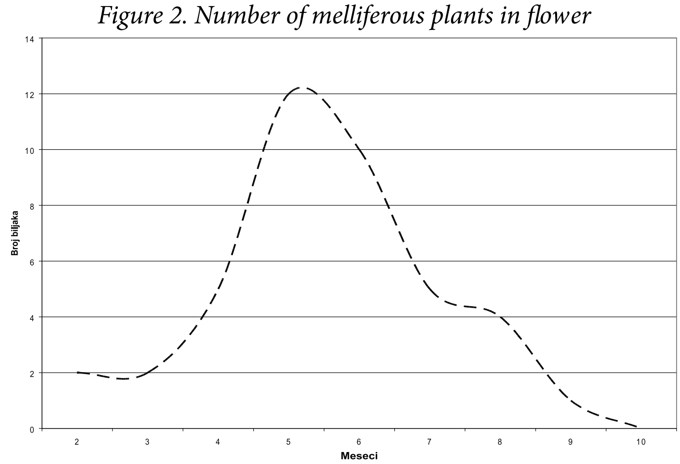
In Balkan maple and spruce forests, there are 47 plant species. Of that number, 24 are medicinal plants. Three species (*Juniperus communis, Sanicula europaea, Betula pendula*) belong to the first category of medicinal plants, 2 species are in the second category (*Veronica officinalis, Pulmonaria officinalis*), in the third - 7 species (*Rubus idaeus, Potentila erecta, Scrophularia nodosa, Fagus silvatica, Helleborus odorus, Asperula odorata, Populus tremula*), in the fourth - 4 species (*Fragaria vesca, Acer heldreichii, Corylus avelanna, Sorbus aucuparia*) and in the fifth - 8 species (*Picea abies, Alchemila vulgaris, Anemone nemorosa, Lilium martagon, Salix capreae, Paris quadrifolia, Ribes grossularia, Trifolium pratense*). The following species are in the trade: *Veronica officinalis, Rubus idaeus, Fagus silvatica, Helleborus odorus, Sorbus aucuparia, Picea abies, Juniperus communis, Sanicula europaea, Betula pendula, Pulmonaria officinalis, Potentila erecta, Fragaria vesca, Corylus avelanna, Asperula odorata* and *Alchemila vulgaris*.

The control of harvesting and trade of wild plant species is mandatory for *Juniperus communis, Sanicula europaea, Betula pendula, Pulmonaria officinalis, Potentila erecta, Fragaria vesca, Corylus avelanna, Asperula odorata* and *Alchemila vulgaris*.

In the forests of Balkan maple and spruce, the following are fruit-tree species: *Juniperus communis, Rubus idaeus, Fragaria vesca, Sorbus aucuparia, Ribes grossularia, Ribes petraeum* and *Sorbus austriacus.*

There are 20 melliferous species, of which 6 trees, 5 shrubs and 9 herbaceous. Mean melliferousness of the community amounts to 2.95. The greatest number of melliferous plants flower in May.

Figure 2. Number of melliferous plants in flower



3. CONCLUSIONS

A stand of Balkan maple *Aceri heldreichii-Piceetum abietis* Mišić et Panić, 1990 (CODE 040303.4-05) was recorded in the area of southwest Serbia, on the peak of the mountain Ozren, at the site Litica (1494 m asl.).

In the Palaearctic site classification, the introduction of a new site with a new code has been proposed:

ILLYRIAN ACER HELDREICHII - SPRUCE FORESTS

– CODE 42.25421

The community is a progradation phase occurring on the site of beech, fir and spruce. The spectre of floral elements is characterised by the dominance of Eurasian (37.78%) and central European floral elements (26.67%). The percentage of Sub-Mediterranean elements is 15.56%, Circumpolar 11.11%, and Arctic and Boreal 6.67%. The Pontic-central Asian floral elements are not recorded in the community.

The highest percentage is that of hemicryptophytes (51.06%). The percentage of phanerophytes is 27.66% (21.28% phanerophytes and 6.38% nanophanerophytes), geophytes 14.89%, herbaceous chamaephytes 4.26% and terrophytes 2.13%. The community is hemi-cryptophyte-phanerophyte.

24 medicinal species are determined. The control of harvesting and trade of wild plant species is mandatory for *Juniperus communis, Sanicula europaea, Betula pendula, Pulmonaria officinalis, Potentila erecta, Fragaria vesca, Corylus avelanna, Asperula odorata* and *Alchemila vulgaris*. The following species are fruit trees: *Juniperus communis, Rubus idaeus, Fragaria vesca, Sorbus aucuparia, Ribes grossularia, Ribes petraeum* and *Sorbus austriacus*.

Of 20 melliferous species, 6 are trees, 5 shrubs and 9 are herbaceous plants. The mean melliferousness of the community is 2.95.

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ZYGOTIC EMBRYO CULTURE OF *PINUS PEUCE* GRIS.

Dragana STOJIČIĆ[1], Snežana BUDIMIR[2], Dušica JANOŠEVIĆ[3], Branka UZELAC[2]

Abstract: *Isolated embryos of Pinus peuce were grown on Gresshoff and Doy (GD) medium for four weeks. The embryo germination was inhibited by maltose, while sucrose increased the rate of embryo germination. Further seedling development was stimulated on medium supplemented with 3% sucrose. When mature zygotic embryos were grown on GD medium supplemented with cytokinins adventitious bud induction was obtained. Benzyladenine at 0,5 mg/l was optimal for bud induction. Shoot elongation was improved by transferring explants to the growth regulator-free medium containing 5 g/l activated charcoal. After puls-treatment with 1 mM indole-3-butyric acid 15,8% shoots detached from explants were rooted. Rooted plantlets were successfully transferred to ex vitro conditions.*

Key words: Adventitious bud, embryo culture, plant regeneration, seedling.

Macedonian pine, *Pinus peuce* Gris. is relic and endemic to the Balkan Penninsula. This pine usually grows on the mountains of the Balkan Peninsula at altitudes between 800 and 2300 m on slopes on siliceous soils, rarely on carbonate soils (Vidakovic, 1982). The tree is 35-40 m tall, bark on young trees is smooth silvery grey, later becoming darker and rough. There are 5 leaves per fascicle, 4-10 cm long, cones are pendulous 9-20 cm long, cylindric. Seeds are grey-brown, shed as soon as cones mature in October, 12-14 months after pollination.

Macedonian pine seeds are dormant in natural conditions, as well as the seeds of the majority of *Pinus* species. To be able to germinate, Macedonian pine seeds are stratified for six months in cool-moist conditions. As stratification is a complex process, which increases the seedling production costs, efforts are made to ensure a fast, uniform and synchronised seed germination (Cooke et al. 2002). Embryo culture *in vitro* is an increasingly applied method for the successful breaking of dormancy and shortening of the plant growth cycle. The objective of our study was to find an optimal medium through which embryo dormancy could be bypassed.

Macedonian pine possesses numerous remarkable characteristics, such as ecological tolerance and frost resistance that make it very valuable for forest tree breeding (Mitchell, 1996). It is very tolerant to winter cold and also to wind exposure. From the ecological point of view, *P. peuce* is recommended as a melioration tree suitable for planting on degraded and devastated soils. Macedonian pine is also a popular ornamental tree in parks. Because of its limited area of natural distribution, this species requires special attention and implementation of measures for its conservation (Janković, 1991).

P. peuce is usually regenerated by seedlings, partially by rooted cuttings. However, these traditional methods of vegetative propagation are often difficult or impossible. Full seed production is unpredictable and delayed by the time required for a tree to reach its full reproductive capacity. Tissue culture has been recognized as an alternative technique for vegetative propagation. There are

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several methods for *in vitro* plant regeneration such as adventitious or axillary bud induction and somatic embryogenesis. To our knowledge, the micropropagation of *P. peuce* has not been reported previously. In an attempt to elaborate methods for adventitious bud induction, shoot elongation and root induction, effects of several factors for micropropagation of Macedonian pine were examined.

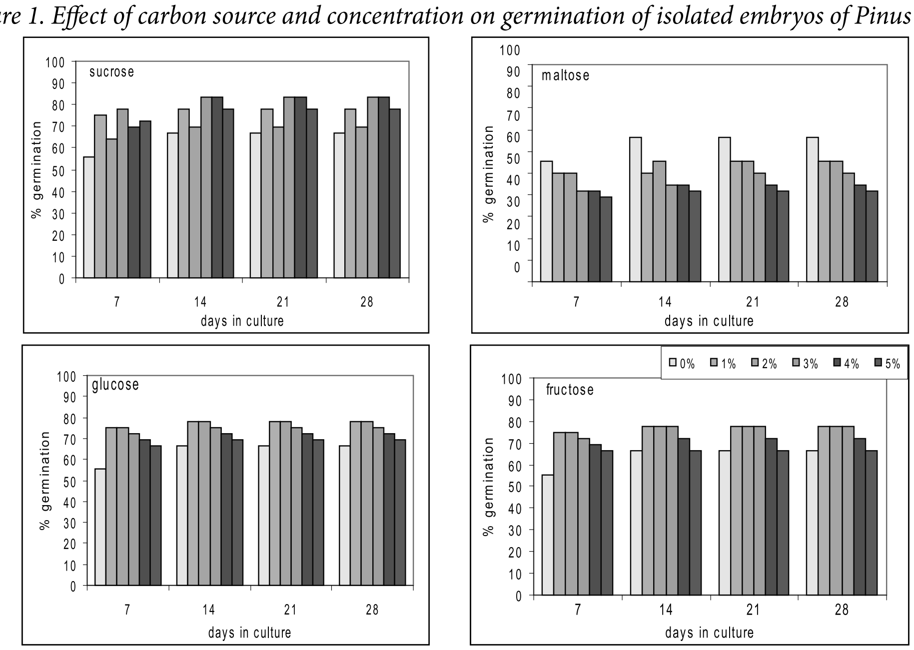
Cones of *P. peuce* were harvested from open-pollinated trees located on Mučanj Mountain, during October 2000 and 2004. Seeds were extracted from the cones and kept at 4 °C. After surface-sterilization in 20% sodium hypochlorite for 30 minutes, seeds were rinsed three times with sterile distilled water, and then seed coats were removed. The embryos were aseptically isolated from megagametophyte and placed horizontally on the surface of the GD (Gresshoff and Doy, 1972) medium as modified by Sommer et al. (1975).

For the study of embryo germination, embryos were grown 4 weeks on the GD medium supplemented with 0,7% agar (Torlak, Belgrade) and 0, 1, 2, 3, 4, or 5% sucrose, glucose, fructose or maltose. There were two replicates per treatment, each consisting of 18 embryos, total 36 embryos for each treatment.

For adventitious bud induction 30 embryos per treatment were placed on GD medium supplemented with 0.7% agar, 3% sucrose and BA at various concentrations (0.5, 1.0, 2.5 or 5.0 mg/l). Also, the effect of kinetin and combination of BA + kinetin on bud induction was tested. Explants were kept on induction medium for 4 weeks, and then transferred to the same basal medium but at half-strength, growth regulator-free, containing 5 g/l activated charcoal (AC) to promote bud elongation. Two rooting methods were used. Firstly, shoots were cultured on 1/2 GD with 2% sucrose and supplemented with (a) non, (b) 0,5% AC, (c) 0,27 or 1,08 µM NAA (d), 0,25 or 0,98 µM IBA. Shoots were cultured for 4 weeks on these media and then transferred to 1/2 GD medium with 2% sucrose. Secondly, shoots were pulse treated with a solution of 1mM NAA or IBA for 2 or 5 h. After puls-treatment, shoots were transferred to 1/2 GD supplemented with 2% sucrose. There were two replicates per treatment, each consisting of 30 explants, total 60 explants for each treatment.

The embryos of *Pinus peuce*, with the removed testa and endosperm, germinated *in vitro*, on the appropriate culture media, after 24 hours without any previous treatments. The culture

Figure 1. Effect of carbon source and concentration on germination of isolated embryos of Pinus peuce



medium composition optimal for Macedonian pine embryo germination and seedling growth is determined empirically. The study parameters were: the percentage of germinated embryos, length of the seedlings and their fresh and dry mass. Macedonian pine embryos germinated (67 %) on the media without carbon source, but the absence of carbohydrates caused slower seedling growth (figure 1). Seedlings grown on the medium without sugar were etiolated, physiologically weakened, but all of them succeeded in surviving for four weeks in such culture conditions. This finding is different from that of the other studies. The isolated mature embryo of *P. radiata* could not germinate on the medium without any carbohydrate (Lin and Leung, 2002). Macedonian pine embryo germination was stimulated by the media with sucrose, glucose or fructose, while the media with maltose inhibited the process (figure 1).

The media with high concentration of maltose were watery and viscous, so the embryos were soaked in the medium. In such conditions, the inhibited gas exchange caused the necrosis of embryos and, later on, of the seedlings tissue, which resulted in the reduced explant growth. The embryo germination, length of plantlet, as well as fresh and dry weight, were greater when embryos were cultured on medium supplemented with sucrose compared to the media with maltose, glucose or fructose (table 1). The optimal medium for Macedonian pine embryo germination and seedling growth was GD supplemented with 3% sucrose.

Table 1. Effect of carbon source on the growth of plantlets of Pinus peuce

Carbon source	Plantlet lenght (mm)	Fresh weight (mg)	Dry weight (mg)
Sucrose (%)			
0	24,33 ± 1,31a	33,92 ± 2,52a	5,25 ± 0,46a
1	32,50 ± 0,96b	50,89 ± 3,12b	8,00 ± 0,50a
2	36,44 ± 1,84bc	50,60 ± 3,80b	14,76 ± 1,27b
3	42,97 ± 4,02c	54,13 ± 3,14b	14,77 ± 1,32b
4	33,53 ± 2,88b	47,50 ± 2,63b	14,70 ± 1,26b
5	31,86 ± 1,96b	52,11 ± 3,17b	13,68 ± +1,21b
Maltose (%)			
0	24,33 ± 1,31a	33,92 ± 2,52a	5,25 ± 0,46a
1	34,20 ± 1,13c	35,50 ± 2,60a	9,85 ± 0,58b
2	30,40 ± 1,15b	36,30 ± 2,28a	11,65 ± 0,58ab
3	29,88 ± 1,55b	39,39 ± 3,11a	14,06 ± 0,99c
4	22,44 ± 0,59a	40,63 ± 4,50a	13,13 ± 1,25c
5	21,60 ± 0,99a	38,33 ± 3,84a	13,87 ± 1,23c
Glucose (%)			
0	24,33 ± 1,31a	33,92 ± 2,52a	5,25 ± 0,46a
1	34,43 ± 0,96c	38,82 ± 2,07a	8,82 ± 0,39b
2	29,36 ± 1,84b	39,89 ± 1,78a	11,68 ± 0,69d
3	27,48 ± 4,02ab	34,07 ± 2,25a	10,70 ± 0,58cd
4	24,08 ± 2,88a	33,35 ± 1,89a	9,58 ± 0,37bc
5	24,24 ± 1,96a	34,20 ± 2,09a	10,72 ± 0,43cd
Fructose (%)			
0	24,33 ± 1,31a	33,92 ± 2,52a	5,25 ± 0,46a
1	33,67 ± 1,35c	44,13 ± 2,32b	12,12 ± 0,39b
2	30,42 ± 1,68c	42,81 ± 2,40b	11,68 ± 0,69b
3	27,74 ± 2,02b	39,05 ± 2,27b	12,00 ± 0,58b
4	23,48 ± 2,35a	34,67 ± 2,10a	6,28 ± 0,37a
5	22,97 ± 2,21a	34,15 ± 2,12a	,08 ± 0,43a 7

Means in the column followed by different letters are different according to Duncans' Multiple Range Test ($p \leq 0.05$)

The regeneration of *Pinus peuce* was achieved by the induction of adventitious buds *in vitro*. The culture medium used for the induction of adventitious buds on Macedonian pine explants was GD supplemented with cytokinin, benzyladenine (table 2). The highest average number of buds on Macedonian pine explants was formed under the effect of 0.5 mg/l BA. The increase of BA concentration caused the decrease in the number of buds formed on the treated explants. The measurement of bud length shows the correlation between the number and the length of adventitious buds. The buds formed on explants treated with 0.5 mg/l BA respectively had the highest average length. The increase of benzyladenine concentration caused the formation of the lower number of buds, which were also shorter (table 2).

Table 2. The effects of BA concentration on adventitious bud formation and elongation using GD as basal medium

BA (mg/l)	Explants with buds (%)	Average no. of buds per explant x ± SE	Average shoot length (mm)* x ± SE
0.5	100.0	15.12 ± 0.99c	3.77 ± 0.69c
1.0	93.3	12.95 ± 1.03b	3.03 ± 0.78bc
2.5	83.3	10.40 ± 0.95a	2.75 ± 0.80b
5.0	46.7	10.10 ± 0.91a	2.32 ± 0.80a

Means in the column followed by different letters are different according to Duncans' Multiple Range Test ($p \leq 0.05$) *Shoot length was measured 16 weeks after culture establishment. SE = standard error.

In addition to benzyladenine, we also tested the effects of other cytokinins and their combinations on the formation of adventitious buds. The results show that the most efficient results were achieved with BA (table 3). BA was also the most effective cytokinin for bud induction in *Pinus heldreichii* (Stojičić et al. 1999, Budimir et al. 2002).

Table 3. Effect of cytokinins on bud induction. Explants were grown on GD for 4 weeks and then transferred to the bud elongation medium for another 4 weeks

Cytokinins (mg/l)	Explants with buds after 8 weeks in culture (%)	Average no. of buds per explant x ± SE
BA 1.0	93.3	12.95 ± 1.03b
BA 0.5	100.0	15.12 ± 0.99c
kinetin 0.5 + BA 0.5	98.3	5.33 ± 0.83a
kinetin 0.25 + BA 0.25	95.0	5.12 ± 0.85a
kinetin 1.0	100.0	5.46 ± 0.86a
kinetin 0.5	100.0	5.32 ± 0.65a

Means in the column followed by different letters are different according to Duncans' Multiple Range Test ($p \leq 0.05$). SE = standard error.

Shoots elongated after transfer to a GD medium containing 2 g/l activated charcoal and no growth regulators. Activated charcoal absorbs the exogenously supplemented phytohormones and phenol compounds. A greater number of elongated buds was obtained when the explants, with each successive transfer to the fresh medium, were divided into smaller pieces. In this way, the explants had the possibility of greater absorption from the media, but also the density of the surrounding buds was reduced. The rooting of adventitious buds is difficult and with many problems. Only a small number of conifer species root spontaneously. Adventitious buds of Macedonian pine are induced on rhizogenesis by using the half-strength medium supplemented with activated charcoal. However, the percentage of rooted shoots was low. The induction of rhizogenesis on Macedonian pine buds is also attempted by supplementing of auxin NAA and

IBA. Auxins in culture media did not cause root induction, but the development of callus in the basal area. Rooting with IBA and NAA solution pulse treatment was successful. After puls-treatment with 1 mM indole-3-butyric acid 15,8% shoots detached from explants were rooted. Rooted plantlets were successfully acclimatized.

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