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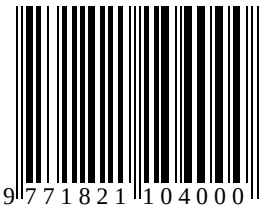

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CONTENT SADRŽAJ
TOM 67-68

Ljiljana BRAŠANAC-BOSANAC, Tatjana ĆIRKOVIĆ-MITROVIĆ
AIR TEMPERATURE CHANGES IN SERBIA IN PERIOD 1949-2010 IN VIEW OF GLOBAL CLIMATE CHANGES 7

Milorad VESELINOVIĆ, Suzana MITROVIĆ, Dragana DRAŽIĆ, Dragica STANKOVIĆ, Snežana RAJKOVIĆ, Biljana NIKOLIĆ, Nevena ČULE
CERTAIN HISTOLOGICAL CHARACTERISTICS OF DOUGLAS-FIR NEEDLES IN DIFFERENT HABITATS 15

Vera LAVADINOVIĆ, Vladan POPOVIĆ, Emil POPOV, Vukan LAVADINOVIĆ
TESTING OF CANADIAN DOUGLAS-FIR HEIGHT IN JUVENILE PHASE 23

Renata GAGIĆ SERDAR, Radovan NEVENIĆ, Goran ČEŠLJAR, Svetlana BILIBAJKIĆ, Tomislav STEFANOVIĆ, Zoran PODUŠKA, Ilija ĐORĐEVIĆ
THE MOST COMMON FOREST PHYTOCOENOSIS ENDANGERED BY FALSE INDIGO SPREADING IN SERBIA 33

Miloš KOPRIVICA, Bratislav MATOVIĆ, Vlado ČOKEŠA, Snežana STAJIĆ
STAND VOLUME TABLES FOR BEECH IN SERBIA 45

Snežana STAJIĆ, Vlado ČOKEŠA, Zoran MILETIĆ
STAND CONDITION AND SILVICULTURAL NEEDS IN ARTIFICIALLY ESTABLISHED EASTERN WHITE PINE STAND (*Pinus strobus* L.) IN THE BOGOVAĐA REGION 59

Goran ČEŠLJAR, Radovan NEVENIĆ, Svetlana BILIBAJKIĆ, Tomislav STEFANOVIĆ, Renata GAGIĆ SERDAR, Ilija ĐORĐEVIĆ, Zoran PODUŠKA
VIABILITY OF TREES ON BIO-INDICATOR PLOTS LEVEL -A 1 IN REPUBLIC OF SERBIA IN 2013 69

Radovan NEVENIĆ, Svetlana BILIBAJKIĆ, Miroslava MARKOVIĆ, Goran ČEŠLJAR, Tomislav STEFANOVIĆ, Ilija ĐORĐEVIĆ, Zoran PODUŠKA **TREE CROWN CONDITION AT LEVEL II SAMPLE PLOTS KOPAONIK, CRNI VRH AND MOKRA GORA IN 2013** 79

Tomislav STEFANOVIĆ, Svetlana BILIBAJKIĆ, Radovan NEVENIĆ, Ilija ĐORĐEVIĆ, Zoran PODUŠKA,Goran ČEŠLJAR, Renata GAGIĆ SERDAR
RESULTS OF RESEARCH OF DEFOLIATION ON BIO-INDICATOR PLOTS IN REPUBLIC OF SERBIA IN 2013 95

Nevena ČULE, Dragana DRAŽIĆ, Milorad VESELINOVIĆ,
Ljiljana BRAŠANAC-BOSANAC, Suzana MITROVIĆ, Marija NEŠIĆ
BIOLOGICAL RECLAMATION OF LANDSCAPE DEGRADED BY SURFACE MINE EXPLOITATION - CASE STUDY OF COAL SURFACE MINE „TAMNAVA – ZAPADNO POLJE“ 103

Mihailo RATKNIC, Tatjana RATKNIC, Zoran MILETIC,
Vlado COKESA, Snezana STAJIC, Sonja BRAUNOVIC,
Tatjana CIRKOVIC-MITROVIC
CHANGES OF FOREST HABITATS DESTROYED BY FIRE AND THE RATE OF NATURAL REVITALISATION OF DAMAGED ECOSYSTEMS 117

Svetlana BILIBAJKIĆ, Tomislav STEFANOVIĆ, Radovan NEVENIĆ,
Goran ČEŠLJAR, Renata GAGIĆ SERDAR, Zoran PODUŠKA,
Ilija ĐORĐEVIĆ
ANALYSIS OF SILTATION SLOPE DEPENDENCE ON GRAIN SIZE COMPOSITION OF SEDIMENT IN TORRENT STREAMS OF TRGOVISKI TIMOK DRAINAGE BASIN 133

Mara TABAKOVIĆ-TOŠIĆ
GYPSY MOTH (Lymantria dispar L.) OUTBREAK IN THE CENTRAL PART OF REPUBLIC OF SERBIA IN THE PERIOD 2010-2013 141

Miroslava MARKOVIC, Snezana RAJKOVIC, Radovan NEVENIC,
Aleksandar LUCIC
IMPACT OF THE EDIBLE MUSHROOM ON DESTRUCTION OF OAK WOOD 151

Ilija ĐORĐEVIĆ, Zoran PODUŠKA, Radovan NEVENIĆ,
Renata G. SERDAR, Svetlana BILIBAJKIĆ, Goran ČEŠLJAR,
Tomislav STEFANOVIĆ
ASSESSMENT OF THE SYSTEM OF FUNDING OF PROTECTED AREAS IN THE REPUBLIC OF SERBIA 161

Zoran PODUŠKA, Ilija ĐORĐEVIĆ, Radovan NEVENIĆ,
Svetlana BILIBAJKIĆ, Renata GAGIĆ SERDAR, Goran ČEŠLJAR,
Tomislav STEFANOVIĆ
POSSIBILITIES FOR IMPROVEMENT OF THE MANAGEMENT OF PROTECTED NATURAL AREAS 175

Katarina MLADENOVIĆ, Bojan STOJNIĆ, Slobodan MILANOVIĆ,
Vlado ČOKEŠA, Ivan MILENKOVIĆ
SPECIES COMPOSITION OF SPIDER MITES AND PREDATORY MITES (Acari: Tetranychidae, Phytoseiidae) OCCURRING ON CRAB APPLE (*Malus silvestris* Mill) IN SERBIA 187

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STAND CONDITION AND SILVICULTURAL NEEDS IN ARTIFICIALLY ESTABLISHED EASTERN WHITE PINE STAND (*Pinus strobus L.*) IN THE BOGOVAĐA REGION

Snežana STAJIĆ[1], Vlado ČOKEŠA[1], Zoran MILETIĆ[1]

Abstract: *The paper presents the condition of the artificially established eastern white pine stand (Pinus strobus L.), planted in the Hungarian oak and Turkey oak with hornbeam forest site (Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979). The stand is located within the Bogovađa forest complex, which encompasses forests and forest lands owned by the Bogovađa Monastery. Based on the study of the environmental and stand conditions, as well as the development of individual trees, the extent of use of the site production potential by this species was analysed, and whether its use for reconstruction of Hungarian oak and Turkey oak coppice forests in this area proved justified.*

Key terms: eastern white pine, Hungarian oak and Turkey oak forest, stand condition, tree development, Bogovađa.

SASTOJINSKO STANJE I UZGOJNE POTREBE U VEŠTAČKI PODIGNUTOJ SASTOJINI BOROVCA (*Pinus strobus L.*) NA PODRUČJU BOGOVAĐE

Izvod: *U radu je prikazano stanje veštački podignute sastojine borovca (Pinus strobus L.), podignute na staništu sladuna i cera sa grabom (Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979). Sastojina se nalazi u šumskom kompleksu Bogovađa, koji obuhvata šume i šumsko zemljište koje su u vlasništvu manastira Bogovađa. Na osnovu proučenih uslova sredine i sastojinskog stanja, kao i razvoja pojedinačnih stabala analizirano je u kojoj meri ova vrsta koristi proizvodni potencijal staništa, i da li se pokazalo opravdanim koristiti je prilikom rekonstrukcije izdanačkih šuma sladuna i cera na ovom području.*

[1] Institute of Forestry, Kneza Viseslava 3, Belgrade.

Ključne reči: Borovac, šuma sladuna i cera, sastojinsko stanje, razvoj stabala, Bogovađa.

1. INTRODUCTION

Previous criteria for introduction of various coniferous species in the oak forest belt, performed in the mid 20th century, were based on the coniferisation strategy, where paying insufficient attention to complex properties of vegetation-forest eco-systems resulted in plantation of conifer monocultures. The coniferous species most commonly introduced in beech and oak forests in Serbia, in the process of land amelioration, were pines – black and white and, to a lesser extent, spruce. Since the 1970s, other coniferous species were increasingly used in smaller areas: Eastern white pine (*Pinus strobus* L.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), European larch (*Larix decidua* Mill.), Balsam fir (*Abies concolor* Lindl. et Gord.) and other species, without previous assessment of their suitability for specific forest sites. That resulted in an occurrence of a mass dieback of introduced coniferous species and, in some instances, in a complete deterioration of these cultures. As Stilinović, S. (1988) states, the most reliable method in selection of species used for afforestation and land amelioration is prior establishing of sample plots on representative areas. Given the fact that these species are not homogenous natural entities in biological, silvicultural and production terms, they must be assessed under conditions of a concrete forest site and, in that manner, their suitability for a given forest site should be determined.

In the area of the Bogovađa forest complex, works on land amelioration of coppice forests have already been performed. Intensive works on reconstruction of coppice forests, by means of introduction of fast-growing conifers, primarily domestic pines, eastern white pine, Douglas-fir and larch, were initiated in 1964.

2. STUDY OBJECT, MATERIAL AND WORK METHOD

'Bogovađa' Management Unit is located in the upper upstream part of the Kolubara Basin, at approximately 4km point-to-point distance from the confluence of the River Ljig with the River Kolubara in the south. The studies were conducted through a series of sample plots planted in the artificially established eastern white pine stand (*Pinus strobus* L.), in the 40 years old Hungarian oak and Turkey oak with hornbeam forest site – *Carpino betuli- Quercetum farnetto-cerris,* for the purpose of establishing to what extent the introduction of the above-mentioned species into this forest site was justified.

The basic climatic characteristics of the studied locality are characterised by the following values: the mean annual temperature is 10.7º (in the vegetation period 16.9º), the annual amount of precipitation is 836.8 mm, while the relative air humidity ranges between 67 and 80%. According to the Thornthwaite climatic classification, the climate of the area is mid-humid.

According to the research by Antić, M. i Marković, D., (1971), the geological layer of the area consists of lake sediments (marl and claystone), while

the soil in the analysed stand is deeply loess-affected with elements of pseudogley (Stajić, S. et al., 2008).

Gathering of taxation data was conducted according to a standard work method. A detailed analysis of the forest site and stand condition was performed; additionally, a cut down of required number of trees among the thickest 20% was carried out in each series of sample plots for the purpose of dentrometric analysis,.

The stand quality was determined according to a standard silvicultural methodology of the Faculty of Forestry in Belgrade (estimate of biological position, stem quality and crown quality).

Data processing was conducted according to a standard work method for this type of study.

3. STUDY RESULTS AND DISCUSSION

3.1 Forest site and stand basic data

The analysed eastern white pine stand (*Pinus strobus* L.) is situated at the altitude of 210m, the exposition is northern, the inclination very mild, less than 3º. The stand is 40 years old; canopy closure is 0.8-0.9. In addition to eastern white pine, the tree layer includes lime tree, of seed origin, occurring naturally, with a large number of good-quality trees.

3.2 Stand condition and structure

The total number of trees in the studied stand ranges between 975 and 1,150 per *ha*, or 1,062 per *ha* (Table 1) on average. The percentage representation of eastern white pine in the stand accounts for 73.0%. The number of lime trees ranges between 150 and 350 per *ha*, or 287 per *ha* on average, which accounts for 27% of the total number of trees in the stand.

The total basal area in the analysed stand ranges between 42.89 m^2/ha and 51.02 m^2/ha, or, 46.01 m^2/ha on average. The eastern white pine basal area ranges between 30.96 and 40.90 m^2/ha, or 36.63 m^2/ha (79.6%) on average. The representation of lime tree in the basal area is in the range between 12.9 and 28.2%, and, on average, it amounts to 9.37 m^2/ha (6.05 do 12.62 m^2/ha), or, in percentage, 20.4% of the stand total basal area.

The total volume of the stand ranges between 365.96 and 524.25 m^3/ha, or 455.82 m^3/ha on average. The lime tree average volume amounts to 101.4 m^3/ha, and it ranges between 66.66 and 135.32 m^3/ha.

Table 1. *Basic data on analysed stand*

	Management Unit: "Bogovađa", branch: 18c						Sample plot: I						Altitude: 210 m					
	Inclination: 3º						Exposition: northern						Stand age: 40 years					
Artificially established eastern white pine stand (*Pinus strobus L.*) in the Hungarian oak and Turkey oak with hornbeam forest site (Carpino betuli - *Quercetum farnetto-cerris) on a deeply loess-affected soil with elements of pseudogley*																		
Diam. class	Eastern white pine						Lime tree						Total					
	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	%
	INITIAL CONDITION																	
7.5							44	15.4	0.19	2.1	2.28	2.2	44	4.1	0.19	0.4	2.28	0.5
12,5	13	1.7	0.15	0.4	1.13	0.3	37	12.9	0.46	4.9	5.16	5.1	50	4.7	0.61	1.3	6.29	1.4
17.5	75	9.7	1.80	4.9	15.48	4.4	50	17.4	1.20	12.8	13.25	13.1	125	11.8	3.01	6.6	28.73	6.3
22.5	381	49.2	15.16	41.4	141.99	40.1	112	39.0	4.47	47.7	48.53	47.9	493	46.4	19.63	42.7	190.52	41.8
27.5	250	32.2	14.85	40.5	147.87	41.7	25	8.7	1.48	15.8	15.85	15.6	275	25.9	16.33	35.5	163.72	35.9
32.5	56	7.2	4.67	12.8	47.95	13.5	19	6.6	1.56	16.7	16.33	16.1	75	7.1	6.23	13.5	64.28	14.1
total	**775**	**100.0**	**36.63**	**100.0**	**354.42**	**100.0**	**287**	**100.0**	**9.37**	**100.0**	**101.40**	**100.0**	**1062**	**100.0**	**46.01**	**100.0**	**455.82**	**100.0**
	TREES MARKED FOR THINNING																	
12.5	13	7.3	0.16	2.6	1.1	2.1	13	13	0.15	4.2	1.72	4.4	25	9.1	0.31	3.2	2.85	3.1
17.5	63	35.6	1.50	25.6	12.7	24.4	19	19	0.45	12.5	4.97	12.7	81	29.5	1.95	20.6	17.69	19.4
22.5	88	49.7	3.48	59.2	31.4	60.2	62	62	2.49	68.9	26.96	69.0	150	54.5	5.97	62.9	58.38	63.9
27.5	13	7.3	0.74	12.6	6.9	13.3							13	4.7	0.74	7.8	6.94	7.6
32.5							6	6	0.52	14.4	5.44	13.9	6	2.2	0.52	5.5	5.44	6.0
total	**177**	**100.0**	**5.88**	**100.0**	**52.2**	**100.0**	**100**	**100.0**	**3.61**	**100**	**39.09**	**100.0**	**275**	**100.0**	**9.48**	**100.0**	**91.29**	**100.0**
	Representation N=22.8% per: G=16.2% V=14.7%						Representation N=34.8% per: G=38.5% V=38.6%						Representation N=25.9% per: G=20.6% V=20.0%					

The average current volume increment amounts to 16.2 *m3/ha*, and it ranges between 12.6 and 18.5 *m3/ha*, while the increment percentage accounts for 3.53%.

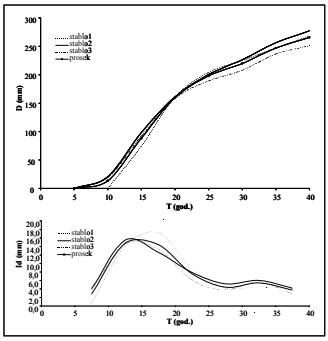
The obtained results correspond to the research results presented by Stojanović, Lj. et al. (1994) for the artificially established eastern white pine stands in the Kučevo area, as well as to the results presented by Koprivica, M., i Ratknić, M. (1996) for the area of Loznica.

3.3. Tree development

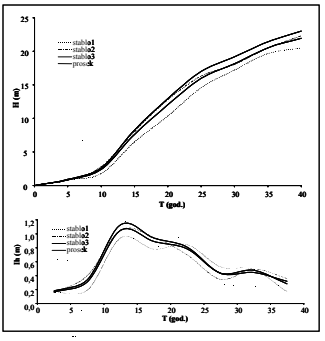
Three eastern white pine trees, whose diameter and height approximately correspond to the mean diameter and the mean height of the stand dominant class trees (the thickest 20%), were analysed. The analyses of diameter and height development, along with diameter and height increment, are presented in the Graphs 1 and 2.

The path of the diameter growth line indicates an intensive increase until the year 20, after which the growth becomes more balanced. In the most advanced analysed age, the attained diameter values were between 25.1 and 27.8 *cm*, or on average 26.6 *cm*. The culmination of the current diameter increment took place in the period between the year 10 and the year 15 (10-20 for individual trees) and it has value of 14.8 *mm*, while the average diameter increment culminates later, approximately at the age of 20, and it has an average value of 8.0 *mm*. The culmination values are slightly lower than the values recorded in the eastern white pine cultures established in the beech forest site in the Arilje area, as well as the values of cultures in Debeli Lug, established on a sessile oak forest site Vučković, M. et al., 1994). In the area of Kučevo Stojanović, Lj. et al. (1994) recorded slightly earlier culmination of the current diameter increment, with a higher value of 16.0 mm.

Following the culmination, the current increment shows a declining trend, with smaller oscillations after the year 25, which is obviously the result of thinning felling conducted on two occasions in that period, which had no significant effect on increase of increment.



Graph 1. *Diameter development of dominant trees and current diameter increment*



Graph 2. *Height development of dominant trees and current height increment*

The total and the current height increment of the analysed eastern white pine trees are presented in the Graph 2. Based on the line of the total height growth, it can be noted that the height growth rate is slightly slower until the year 10, it is followed by a sharp increase that continues until the year 25, after which a slightly slower growth ensues.

The culmination of the current height increment takes place approximately in the year 12, and it has an average value of 1.05 *m*. The culmination of the average increment took place later, approximately in the year 25 (for individual trees between the year 20 and 25) and it has an average value of 0.64 *m*. The identical values for the current height increment, as well as the culmination period, were presented by Vučković, M. et al. (1994) for eastern white pine cultures in Debeli Lug, established in the sessile oak forest site. In terms of heights attained in the year 25, there are no significant differences either, but they are considerably lower than the heights stated by the same authors for eastern white pine cultures in the Arilje area, established on a beech forest site. Rakonjac et al. (2003) recorded lower values of the current height increment of 0.8 *m* in the artificially established eastern white pine stand in the Pešter Plain region, while the culmination took place slightly later, approximately in the year 14.

As it is the case with diameter increment, the height increment after culmination sharply drops, with smaller oscillations.

3.4 Quality and health condition of analysed stands

More than half of eastern white pine trees are situated in the dominant layer – 52.8%, 36.6% in the second and 10.6% of the trees belong to the understory category. It is a similar case with lime tree, where 46.1% of trees are in the dominant layer, 38.5% in the second biological position, while 15.4% belong to understory category.

The quality of stems in this stand is mainly good; stems are moderately cleared from branches up to 1/3 of the tree height. Eastern white pine trees are mainly straight and solid, with a stem of a good quality and such trees account for 72.4% of the total eastern white pine trees in the stand. Certain individual trees possess defects, which places them into the category of trees of a medium stem quality, and they account for 19.5% of the total number of eastern white pine trees, while 8.1% of the trees have the stem of a poor quality, which largely concerns mechanical damage occurred due to snowbreak, while an occurrence of decay was also observed in individual trees. With respect to lime tree, only 28.2% of trees have the stem of a good quality, whereas the equal number of trees, 35.9% each, have medium and poor stem characteristics. The most common defects that served as the basis for this type of assessment, concerned curvature and forks, which are common for nearly every tree, while mechanical damage, occurred during felling of neighbouring trees, is also present.

Table 2. *Representation of trees according to biological position, stem and crown quality (%)*

Species	I	II	III
Biological position			
Eastern white pine	52.8	36.6	10.6
Lime tree	46.1	38.5	15.4
Stem quality			
Eastern white pine	72.4	19.5	8.1
Lime tree	28.2	35.9	35.9
Crown quality			
Eastern white pine	4.1	50.4	45.5
Lime tree	23.1	53.8	23.1

The quality of crowns in this stand is mainly poor, eastern white pine crowns are mostly too narrow, asymmetrical and of an insufficient size. The condition of lime tree is slightly better, although its crowns are also asymmetrical and mainly too wide. Only 4.1% of eastern white pine trees have crowns of good quality, 50.4% of medium quality and even 45-5% of crowns is of poor quality. Lime tree has an equal percentage of crowns of good and poor quality (23.1%), while 53.8% of trees have crowns of medium quality.

The health condition of the stand is assessed as unsatisfactory, given that occurrence of dieback is observed in a large number of trees.

3.5 Proposal of silvicultural measures

The artificially established eastern white pine stand in the Hungarian oak and Turkey oak with hornbeam forest site (*Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979) exhibited good productivity under these conditions; however, based on the diminished vitality of trees and poor health condition of the stand, it can be concluded that site conditions do not suit this species, hence, the re-introduction of autochthonous vegetation, after planned conifer rotation, is proposed as a long-term silvicultural objective.

It is evident that thinning performed in this stand was of a low intensity and untimely, which resulted in formation of trees of great thinness, and with reduced crowns. Such condition additionally endangered biological balance in the stand, which resulted in diminished resistance of trees to damage caused by snow and wind, to which this species is highly sensitive. Untimely performance of thinning also resulted in a decline of the value of the diameter and height increment, while thinning conducted slightly later did not have a significant effect on their dynamics. Based on the time of culmination, it can be concluded that the first thinning in this stands should have been performed after the culmination, approximately in the year 15.

For the purpose of the improvement of overall condition of the artificially established eastern white pine stand, a selective mixed thinning was proposed. On average 220 future trees per ha, whose mean diameter is 27.4 cm and mean height 21.4 m, were selected in the stand. The intensity of marking for thinning was mainly moderate to high and on average accounted for 25.9% in terms of number of trees and approximately 20% in terms of volume. Given the fact that a large

number of trees with the signs of dieback are present in the stand, it was necessary to conduct thinning of a slightly higher intensity in the segments in which the dieback was more pronounced, in order to improve the current condition. Eastern white pine trees with signs of dieback were removed, cleaned from snow and wind, as well as all those of insufficient growth, currently endangering future trees. With respect to lime tree, first of all, a negative selection was performed by removing all trees with any impact on future trees, as well as those of poor quality. In the analysed stand, the eastern white pine slenderness coefficient, which indicates stability of the stand, that is, a potential endangerment by wind and snow, ranges between 80 and 85. Based on the above-mentioned, the performed thinning will not endanger stability of the stand, given the fact that the intensity of the treatment was within the range of 25%, both in terms of number of trees and the volume.

4. CONCLUSION

The artificially established eastern white pine stand was planted in the process of reconstruction of this forest complex in the 1960s.

The total number of trees in the stand ranges between 975 and 1,150 per *ha*, or 1,062 per *ha* on average. The total basal area in the studied stand ranges between 42.89 m^2/ha and 51.02 m^2/ha, or 46.01 m^2/ha on average. The total volume in the stand ranges between 365.96 and 524.25 m^3/ha, or 455.82 m^3/ha on average. The current volume increment amounts to 16.2 *m3/ha* on average, and ranges between 12.6 and18.5 *m3/ha*, while the increment percentage accounts for 3.53%.

The culmination of the current diameter increment in the studied trees took place in the period between year 10 and year 15 (10-20 for individual trees) and it has the value of 14.8 *mm,* while the average diameter increment was attained later, approximately in the year 20, and that value amounts to 8.0 *mm* on average. The culmination of the current height increment occurs approximately in the year 12, and it has an average value of 1.05 *m*. The culmination of the average increment took place later, approximately in the year 25 (in some trees between the year 20 and 25) and it has an average value of 0.64 *m*.

The quality and health condition of the stand is not satisfactory. The quality of stem is mainly good, and 72% of trees have the stem of good quality. The quality of crowns is poor, only 4.1% of eastern white pine trees have crowns of the best quality, while even 45.5% have crowns of the worst quality (of insufficient size, asymmetrical, etc.). Such a poor quality of crowns is partly caused by non-performance of adequate silvicultural measures in the stand, which resulted in a reduced space for growth and formation of small crowns.

For the purpose of improvement of the general condition in the studied stand, a selective mixed thinning should be performed. On average 220 future trees per ha, the mean diameter of which is 27.4 cm, were selected. The intensity of selection was moderate to strong, on average 275 trees per ha were marked, which is 25.9% in terms of number of trees, and 20% according to the volume.

It can be concluded that this species showed good productivity under these conditions, however, based on the general condition of cultures and diminished vitality of trees, the species cannot be recommended for further works on

substitution of coppice forests under these condition. After the planned rotation, dereconstruction, that is, re-introduction of the autochthonous vegetation, which is at any rate biologically better suited to conditions of these stands, is proposed.

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STAND CONDITION AND SILVICULTURAL NEEDS IN ARTIFICIALLY ESTABLISHED EASTERN WHITE PINE STAND (*Pinus strobus L.*) IN THE BOGOVAĐA REGION

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Summary

The artificially established eastern white pine stand in the Hungarian oak and Turkey oak with hornbeam forest site *(Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979)*, produced good results in terms of growth and increment rate, however, the vitality of eastern white pine trees in this stand is greatly diminished. A large

number of trees exhibited signs of dieback of different intensity, while the additional damage was caused by snow and windbreak. The above-mentioned indicates that eastern white pine is not the species to be recommended for further substitution works under these conditions.

For the purpose of the improvement of current situation, a silvicultural measure *mixed selective thinning,* of a moderate to strong intensity, was proposed. The slenderness coefficient (SC) of eastern white pine trees, which indicates the stability of stand, that is, a potential exposure to wind and snow, ranges between 80 and 85 in this stand. Based on the above-mentioned, it can be concluded that the performed thinning will not endanger the stability of stand, given the fact that the intensity of treatment on eastern white pine trees in trial field was within the limit of 25%.

Based on the analysis of trees, and the trend of diameter and height development, it can be noted that the timely thinning was not performed; it was supposed to be carried out approximately in the year 15 – in the period of culmination of the current height increment.

The artificially established eastern white pine stand ought to be tended until the end of the planned rotation, after which a re-introduction of autochthonous vegetation, capable of attaining the maximum use of the stand potential, is recommended.

SASTOJINSKO STANJE I UZGOJNE POTREBE U VEŠTAČKI PODIGNUTOJ SASTOJINI BOROVCA (*Pinus strobus L.*) NA PODRUČJU BOGOVAĐE

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Rezime

Veštački podignuta sastojina borovca na staništu sladuna i cera sa grabom *(Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979)*, pokazala je dobre rezultate u pogledu brzine rasta i prirašćivanja, međutim vitalnost stabala borovca u ovoj sastojini prilično je oslabljena. Dosta stabala je sa znacima sušenja različitog inteziteta, a dodatne štete nastale su od snego i vetroloma. Sve ovo ukazuje da borovac nije vrsta koja bi se mogla preporučiti pri daljim radovima supstitucije u ovim uslovima.

U cilju poboljšanja trenutne situacije kao uzgojna mera predlaže se *mešovita selektivna proreda*, umerenog do jakog zahvata. Koeficijent vitkosti stabala borovca (KV) koji ukazuje na stabilnost sastojine, odnosno na potencijalnu ugroženost prema vetru i snegu u istraživanoj sastojini kreće se u intervalu 80-85. Na osnovu ovoga izvedena proreda neće ugroziti stabilnost sastojine, obzirom da se jačina zahvata kod stabala borovca po oglednim poljima kretala u granicama do 25%.

Na osnovu analize stabala, i tokova razvoja prečnika i visina, primećuje se da je izostala blagovremena proreda u sastojini, koja je trebala biti izvedena oko 15. godine - u vreme kulminacije tekućeg debljinskog prirasta.

Veštački podignutu sastojinu borovca treba negovati do kraja predviđene ophodnje, nakon čega se preporučuje *vraćanje autohtone vegetacije*, koja će u najboljoj meri iskoristiti potencijal ovog staništa.