




УДК / UDC 630
УДК / UDC 635.9
УДК / UDC 674

Online ISSN 1857-9507
www.sf.ukim.edu.mk/sumarski_pregled.htm

ШУМАРСКИ ПРЕГЛЕД
FOREST REVIEW

МЕЃУНАРОДНО НАУЧНО СПИСАНИЕ
INTERNATIONAL SCIENTIFIC JOURNAL

Шум. преглед (Šum. pregled) Год. 47 Бр. 1 Стр. 1-47 Скопје, 2016
For. review Vol. 47 No. 1 Pag. 1-47 Skopje, 2016






УНИВЕРЗИТЕТ „Св. КИРИЛ И МЕТОДИЈ“ ВО СКОПЈЕ
Ss. CYRIL AND METHODIUS UNIVERSITY IN SKOPJE
ШУМАРСКИ ФАКУЛТЕТ ВО СКОПЈЕ
FACULTY OF FORESTRY IN SKOPJE

Online ISSN 1857-9507
www.sf.ukim.edu.mk/sumarski_pregled.htm

УДК / UDC 630
УДК / UDC 635.9
УДК / UDC 674

ШУМАРСКИ ПРЕГЛЕД

FOREST REVIEW

МЕЃУНАРОДНО НАУЧНО СПИСАНИЕ
INTERNATIONAL SCIENTIFIC JOURNAL

Шум. преглед (Šum. pregled)	Год. 47	Бр. 1	Стр. 1-47	Скопје, 2016
For. review	Vol. 47	No. 1	Pag. 1-47	Skopje, 2016

ШУМАРСКИ ПРЕГЛЕД	**FOREST REVIEW**
Меѓународно научно списание	International Scientific Journal
Год. 47, бр. 1 / Стр. 1-47	Vol. 47, No. 1 / Pag. 1-47
Скопје, 2016	Skopje, 2016
Online ISSN 1857-9507	Online ISSN 1857-9507
УДК 630	UDC 630
УДК 635.9	UDC 635.9
УДК 674	UDC 674
Издавач	**Publisher**
Универзитет „Св. Кирил и Методиј“ во Скопје	Ss. Cyril and Methodius University in Skopje
Шумарски факултет во Скопје	Faculty of Forestry in Skopje
в. д. Декан	Acting Dean
Д-р Кирил Сотировски	Kiril Sotirovski PhD
Главен и одговорен уредник	**Editor-in-chief**
Д-р Бојан Симовски	Bojan Simovski PhD

Технички уредник	**Technical editor**
М-р Дејан Манџуковски	Dejan Mandžukovski MSc
Корица и насловна фотографија	**Cover page and photography**
Д-р Бојан Симовски, *Pinus mugo*	Bojan Simovski PhD, *Pinus mugo*
Излегува два пати годишно	Published twice a year
Интернет-страница	**Web page (on-line)**
www.sf.ukim.edu.mk/sumarski_pregled.htm	www.sf.ukim.edu.mk/sumarski_pregled.htm
Адреса на издавачот	**Publisher’s address**
УКИМ-Шумарски факултет во Скопје	UKiM Faculty of Forestry in Skopje
Редакција на Шумарски преглед	Editorial Board of the Forest Review
Ул. „16 Македонска бригада“ бр. 1	Ul. 16 Makedonska brigada br. 1
(П. фах 235)	(P.O. box 235)
1 000 Скопје	MK-1000 Skopje
Република Македонија	Republic of Macedonia
Е-пошта: sumpregled@sf.ukim.edu.mk	E-mail: sumpregled@sf.ukim.edu.mk
www.sf.ukim.edu.mk	www.sf.ukim.edu.mk

ШУМАРСКИ ПРЕГЛЕД	**FOREST REVIEW**
Меѓународно научно списание	International Scientific Journal
Год. 47, бр. 1 / Стр. 1-47	Vol. 47, No. 1 / Pag. 1-47
Скопје, 2016	Skopje, 2016
Online ISSN 1857-9507	Online ISSN 1857-9507
УДК 630	UDC 630
УДК 635.9	UDC 635.9
УДК 674	UDC 674

Интернет-страница	**Web page (on-line)**
www.sf.ukim.edu.mk/sumarski_pregled.htm	www.sf.ukim.edu.mk/sumarski_pregled.htm
Адреса на издавачот	**Publisher's address**
УКИМ-Шумарски факултет во Скопје	UKiM Faculty of Forestry in Skopje
Редакција на Шумарски преглед	Editorial Board of the Forest Review
Ул. „16 Македонска бригада“ бр. 1	Ul. 16 Makedonska brigada br. 1
(П. фах 235)	(P.O. box 235)
1 000 Скопје	MK-1000 Skopje
Република Македонија	Republic of Macedonia
Е-пошта: sumpregled@sf.ukim.edu.mk	E-mail: sumpregled@sf.ukim.edu.mk
www.sf.ukim.edu.mk	www.sf.ukim.edu.mk

For. review 47(1): 1-47. Skopje, 2016
Ss. Cyril and Methodius University in Skopje
Faculty of Forestry in Skopje
ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

CONTENTS

Preface

Original Scientific Articles:

Andrijeski M., Velkovski N., Vasilevski K., Najdovski B.
NUMBER AND QUALITY STRUCTURE OF NATURAL BEECH REGENERATION IN ROUND APERTURES ON BISTRA MOUNTAIN 1

Çoban S., Bayraktar S., Akgül M.
FOREST VEGETATION MAPS AND ITS DEVELOPMENT IN TURKEY: A CASE FROM ISTANBUL-BELGRADE FOREST 7

Delov K., Velkovski N., Andonovski V., Vasilevski K.
TREE CROWN STRUCTURE OF DOUGLASS FIR (*PSEUDOTSUGA MENZIESII* [MIRB.] FRANCO) ON THE KARADZICA MOUNTAIN 17

Vassilev K., Pedashenko H., Velev N.
VEGETATION AND HABITAT DIVERSITY IN ORELYAK RESERVE (SOUTH-WEST BULGARIA) 25

Review Articles:

Sarsekova D., Ayan S., Kitaibekova S.
REVIEW OF DESERTIFICATION AND FOREST DEGRADATION ISSUE IN KAZAKHSTAN 39

Scientific and Professional Meetings:

Rat M., Simovski B., Nikolov B.
ESENIAS-TOOLS WG4 MEETING REPORT: DATA COLLECTION, ANALYSIS, STANDARDISATION AND HARMONISATION ON ALIEN PLANT AND FUNGI SPECIES (3-4 March 2016, Novi Sad, Serbia) 46

Instructions to Authors

For. review 47(1): 17-24. Skopje, 2016
ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm
UDC: 630*22:582.475(497.7:23)
Original scientific article

TREE CROWN STRUCTURE OF DOUGLASS FIR (*PSEUDOTSUGA MENZIESII* [MIRB.] FRANCO) ON THE KARADZICA MOUNTAIN

[1]DELOV K., [2]VELKOVSKI N., [2]ANDONOVSKI V., [2]VASILEVSKI K.
[1]Public enterprise Makedonski sumi, Skopje, Macedonia
[2]Ss. Cyril and Methodius University, Faculty of Forestry in Skopje, Skopje, Macedonia
Corresponding author e-mail address: k.delov@yahoo.com

ABSTRACT: This paper presents the results of surveys and studies of some of the elements that characterize the crown of the trees of Douglass fir (*Pseudotsuga menziesii* [Mirb.] Franco) on Karadzica Mountain. On this mountain the Douglass fir had been introduced in 1967 in the zone of Sessile oak forest, and in its 50 years of development showed very good adaptability and productivity, which exceeds all other introduced non-native tree species, as well as other native tree species. Considering that the crown of the trees of Douglass fir on the Karadzica Mountain has not been studied yet, in this paper the structural elements were analyzed through mathematical-statistical methods and relevant data was obtained for the main structural elements that characterize the crown. The biological position of all the trees was determined, which are grouped into three groups and for all of them following elements have been identified: the width of the crown, chest diameter, the heights of all trees, the absolute length of the crown, the relative length of the crown, horizontal projection of the crowns, the crown index, the coefficient of space for growth and relative space for growth of the tree, depending on the biological position of the trees. The results indicate that in the 50 years of development in the researched forest stand, the trees clearly differentiated into three biological positions with clear patterns in terms of the development of their crowns. However in order to improve the situation in the forest stand and directing their development in the optimum direction it is necessary to perform thinned cuttings in order to regulate the numbers of trees per unit area and their spatial distribution in the forest stand in order to achieve better use of space for the development of the trees.
Keywords: tree crown, Douglass fir, structural elements, Karadzica Mountain.

1 INTRODUCTION

The Douglass fir (*Pseudotsuga menziesii* [Mirb.] Franco) in the scientific literature is described as large and long-living forest tree that has rapid growth and big production of timber. It can reach heights of up to 100 m, 4 m in diameter and age of about 1200 years. Natural range of distribution of Douglass fir are the Pacific regions of North America from British Columbia to California, north to south, on the altitudes up to 900 m. The first samples of Douglass fir in Europe were planted in UK in 1825 (Dzekov 1988).

Douglass fir is the most important introduced tree species for the Macedonian forestry. It has been first time introduced in the beginning of 1960. It is provenance is originally from Oregon (USA).

In the researched area on Karadzica Mountain the Douglass fir was planted in 1967 on northwestern exposure and at the age of 45 years has an average diameter of mean wood (at 1.30 m) of 30.5 cm and a height of 30.0 m. It features good health, great adaptability to the specific natural conditions of the area and the high productivity of the timber which is 621.77 m³ / ha at the age of 45 (Velkovski et el., 2012).

Green Douglass fir is one of the world's most valuable and most important species for wood production (Larson 2010). It is a species that successfully adapts to different external conditions and to retain high growth and enables high production of good quality wood (Weise et al., 2001; Kenk & Thren 1984). Ecological amplitude of green Douglass fir is great, but when creating plantation it should be taken into account the soil type because certain provenances suffered damages of abiotic origin. Therefore choosing the type of provenance in green Douglass fir is very important (Perić et al., 2011).

By studying the results of introduction of conifer tree species in the country, as well as the elements that characterize the crown of the trees by many authors such as: Andonovski, 1978; Ivanovski 1978; Panić 1966; Ristevski 1984 & 1987; Trajkov 1992; Velkovski 1999 & 2007; Mirchevski & Vasilevski 2000; Velkovski et al. 2012; Delov et al. 2014, it suggests that this species is very adaptable and is characterized by much higher productive capacity than other introduced tree species such as: *Pinus strobus* (L.), *Chamaecyparis lawsoniana* (Parl.), *Larix decidua* (Mill.) and *Larix europaea* (DC.), as well as other indigenous tree species *Fagus moesiaca* (Domin, Maly) Chezzot and *Quercus petraea* (Matt.) Liebl..

Crown of trees as one of the main factors for the development of every tree has been studied by a number of authors from home and abroad: (Ivanovski 1971 & 1978; Krstevski, 1975; Andonovski, 1978; Panić 1966; Ristevski 1984 and 1987; Trajkov 1992; Borrmann 1993; Perermann 2000, Velkovski 1999 and 2007; Takenaka 2000, Mirchevski&Vasilevski 2000, Grote 2003; Purves et all. 2007; Schröter 2012; Velkovski et al., 2012; Delov et al. 2014; Krstić et al., 2013 & 2016 and others.

From previous studies on crowns in different tree species on different sites is understood that the crowns can have different sizes of their parts, and also the relationship between the individual parts may be different. These differences are specific to each different tree species and every different site condition and development. The shape and construction of the crown are influenced by a number of factors such as: age of the tree, its location in the plantation, exposure to wind, the genetic characteristics of the species, the application of tending measures in plantations, and other biotic and abiotic factors.

The location of the tree and its exposure to direct sunlight has a substantial impact on the tree crown development and on the other life processes such as assimilation, transpiration, flowering, pollination and fructification. The amount of light exposure on the crown affects its development so the trees that grow in conditions of more light exposure generally have more

ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

ramified crowns which are richer in leaf mass. All the trees in the forest stand have the intention to develop larger canopy in order to gain the greater amount of light and larger living space. However due to the limited space in forest stands there is competition between the trees, so more developed trees and those with better biological position develop larger canopy at the expense of other trees that still lag behind in its development. With increasing age of the trees and the increase of their dimensions the competition among the trees is bigger due to insufficient space in the forest stands and dense canopy those trees that lags in development and has not developed its crowns are lagging even more in their growth and in a certain period they will be completely suppressed by the trees that formed a widely ramified crowns.

This situation will contribute to the gradual withering away of suppressed trees in the forest stand, and those with underdeveloped crowns. The construction of the crown is of great importance in silvicultural activities, because it is a very good indicator of the need for performing tending measures in forest stands. By performing various tending measures the crown development can be influenced, and the living space of the tree can be regulated. It is known that the development of the crowns is used as an indicator of when the start with performing with thinned cuttings. The start of intensive withering away of the lower branches of the tree trunks is a sure sign that it is a time to start performing thinned cuttings (Krstić 2007).

2 MATHERIAL AND METHODS

Douglas fir plantations of which are object of the research in this paper are on Karadzica Mountain, in the central part of Republic Macedonia, west of the river Vardar. The researched area belongs to cold continental climate zone, dominated by the forest association *Orno-Quercetum petraea* Em (Sessile oak forest association).

In the researched area prevails cold continental climate with some influence of the mountain climate. The average annual temperature calculated according to vertical gradients of this area is 8.6 to 9.6 ºC, or an average of about 9º C. The absolute maximum was 41.9º C, while the absolute minimum -19.8ºC. The average annual rainfall ranges from 900 to 940 mm. Data are teken from water stations from Solunska Glava and Katlanovo and processed for 10 years. The geological substrate is a silicate which includes eutric brown forest soils, medium deep, with fresh hummus. Overall natural conditions of the researched area proved to be favorable for the development of Douglass fir.

During 2016 in the plantations of Douglass fir measurements were taken on the elements that characterize the tree crowns. Measurements covered trees of Douglass fir in two test areas with size of 500 m² each located on the site named Kitka. Following parameters were measured: tree diameter at breast height of each tree individually, the heights of all trees, the absolute length of the crown, the radii of the crown towards the four corners of the world (east, west, north and south) and the biological position of trees in three classes (classification according Stojanović & Krstić 2008) with I-class includes the dominant tree, II-class co-dominant trees, III-class suppressed trees. The results are grouped in tree diameter size classes and allocated appropriate biological position of trees in three classes. From the collected data and mathematical and statistical calculations and analyzes following parameters were determined: the average diameter of the crown, the horizontal projection of the crown, the relative length of the crown, the crown index, the coefficient of space for growth and relative space for growth of the tree. The results are presented in appropriate tables and graphs, and appropriate conclusions were drawn from the analyzes and calculations.

Figure 1: Trees of *Pseudotsuga menziesii* at the researched area

3 RESULTS AND DISCUSION

A number of factors affect the elements and the development of the tree crowns, such as the type of tree species, the availability of light to the crown, the age of the tree, location, genetic traits, tending and silvicultural measures taken in the plantation, site condition index, biological position of trees in the forest stand and others. It contributes that for a single tree species in the same forest stand to have trees with different crown construction, which in turn further affect the development of the tree as a whole.

The researched forest stands of Douglass fir are located on altitude of 1112 to 1374 m a.s.l. and on moderately strong inclination slope of the ground from 11-20 °. They are aged 50 years and have a canopy cover of 1.0. The number of sampled trees per hectare in the two test areas (TA-1 and TA-2) was 540 and 820, or average 680 trees per hectare. Of the total number of trees 58% are dominant and belong to the I class, 32% co-dominant belong to the II class, and 10% are suppressed and belong to the III class.

Table I: Number of trees distributed in tree diameter size classes

Tree diameter size classes	TA-1		TA-2		Mean	
	N/ha	%	N/ha	%	N/ha	%
17.5	80	14.8	110	13.4	95	14.0
22.5	60	11.1	150	18.2	105	15.5
27.5	60	11.1	90	11.0	75	11.0
32.5	160	29.7	190	23.2	175	25.7
37.5	100	18.5	190	23.2	145	21.3
42.5	80	14.8	90	11.0	85	12.5
Total	540	100	820	100	680	100

In the research of Krstić et al., (2013) in artificially raised plantations of Serbian spruce with age of 51 years 64% of the trees belonged to I-biological position, 32% were in the II-biological position, and 4% were in III-biological position. In the Serbian spruce seed stand from the area of Srebrenica similar results were obtained, according to which 70.9% of the trees belonged in I-biological position, 25.7% were in the II-biological position, and 3.4% were in the III-biological position, Krstić et al., (2016).

The diameter of the crown represents its widest part. It is determined based on the measured radii of the crowns against the four corners of the world. Then with calculations the average diameter is obtained for each tree diameter size class appropriately allocated towards the biological status of the trees in the forest stand.

The results for the average diameter of tree crowns of Douglass fir is distributed in tree diameter size classes and biological positions are shown in Table II and are presented graphically in Fig. 2.

Table II: Tree crown diameters per diameter size classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Mean diameter in meters						
I			4.76	5.80	6.19	6.54	5.82
II		4.16	4.77	5.75	5.82	6.11	5.32
III	2.92	3.86	4.05	5.16	5.76		4.35

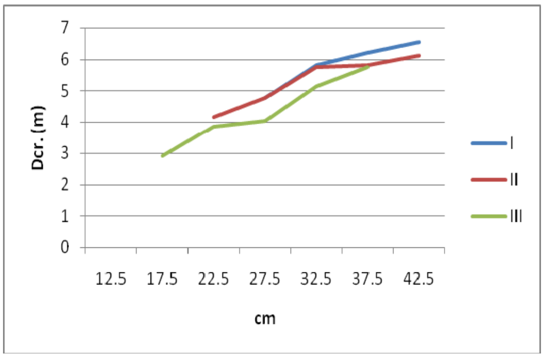

Figure 2: The curves of tree crown diameters per diameter size classes and biological positions

The results for the tree crown diameter presented in Table II and graphically in the Fig.2 show that in all the trees, in whatever biological position there is a trend of increment in the crown diameter with increment of the diameter size class. The biggest i.e. dominant trees have the largest crowns diameters in all diameter size classes. The trees in the III-biological position have the smallest crown diameter, because according to their biological position in the forest stand they are suppressed trees and failed to reach larger diameters and develop their crowns as those co-dominant and dominant trees. The difference in crown diameters between the trees of the I and II-biological position is not very high which indicates more equal development of the crown diameter of these two classes up to the diameter size class of 32.5. Then greater differentiation is observed resulting from the dominant trees in larger diameter size classes that managed to further develop its crowns at the expense of co-dominant and suppressed trees. The biggest mean crown diameter has trees of the I-biological position, which ranges between 4.76 m in the diameter size class of 27.5 and 6.54 m in the diameter size class of 42.5 cm. The mean crown diameter among the trees of the I-biological position is 5.82 m. The mean crown diameter of the trees of the II-biological position varies between 4.16 m in the diameter size class of 22.5 and 6.11 m in the diameter size class of 42.5 cm. The mean diameter among the trees of the II-biological position is 5.32 m. The smallest diameter of the crown have the thinnest trees of III-biological position, found in the diameter size class of 17.5 cm, where the average diameter is 2.92 m and ranges up to 5.76 m in the diameter size class of 37.5 cm. The mean diameter of the crown of the trees from the III-biological position is 4.35 m.

The values of mean crown diameter of Douglass fir are smaller than ever determined values for mean crown diameter of the beech on Maleshevski Mountains ranging between 5.46 m to 8.56 m (Velkovski 2007), the beech on Kozhuv Mountain ranging from 6.00 m to 6.80 m (Ristevski 1984), the beech on the Osogovo Mountains ranging from 5.00 m to 6.90 m (Ivanovski 1978), the beech on Rudnik ranging between 4.40 m and 7.00 m (Panić 1966), mixed forest stands of beech and black pine in the east forest region in Macedonia ranging from 3.40 to 9.00 m (Trajkov 1997), and the mean crown diameters in Giant redwood on Karadzica Mountain ranging from 4.04 m to 6.42 m (Delov et al. 2014). However, they are larger than the crown diameters of Serbian spruce, in the seed stands in the area of Srebrenica, which among the trees of the I-biological position have crown diameters of 1.70 m, among the trees of the II-biological position 1.49 m and in the trees III-biological position the crown diameter was 1.14 m (Krstić et al., 2016). These results are dependent on tree age, canopy, application of tending measures, the density of the forest stands as well as the genetic characteristics of tree species, so some trees form large crowns (beech, etc.), while other naturally form narrow crowns (Serbian. spruce).

Absolute crown length is obtained as the difference of the total height of the tree and the stem length.

Figure 3: Crown length of *Pseudotsuga menziesii*

The results for the absolute crown length of the trees of Douglass fir is distributed in diameter size classes and biological positions of position are presented in Table III and are graphically shown in Fig. 4.

ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

Table III: Absolute crown length, classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Absolute crown lengthin meters						
I			5.00	6.00	7.50	8.25	6.69
II		3.83	4.40	5.50	6.25	6.50	5.30
III	1.00	3.60	4.00	4.50	4.83		3.59

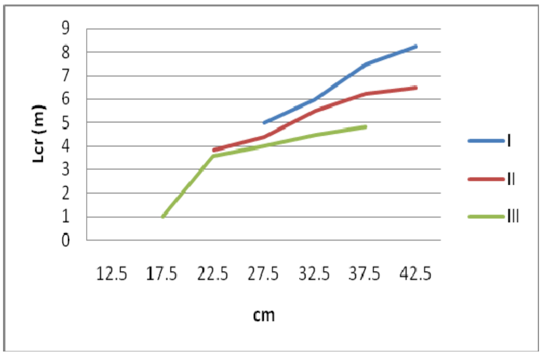

Figure 4: The curves of crown lengths per diameter degrees for different tree social positions

The results on the absolute crown length listed in table III and graphically illustrated in Fig.4 shows that with the increase in their size, the absolute crown length of all trees has also increased, regardless of their biological position. The trees belonging to the I-biological position have the highest absolute crown length ranging from 5.00 m with a diameter degree of 27.5 cm to 8.25 m with a diameter degree of 42.5 cm. The mean absolute crown length of the trees belonging to the first biological position is 6.69 m. The absolute crown length of the trees belonging to the II-biological position ranges from 3.83 m with a diameter degree of 22.5 cm to 6.50 m with a diameter degree of 42.5 cm. The mean absolute crown length of the trees belonging to the second biological position is 5.30 m. The thinnest trees belonging to the III-biological position have the lowest absolute crown length of 1.00 m with a diameter degree of 17.5 cm, and range up to 4.83 m with a diameter degree of 37.5 cm. The absolute crown length of the trees belonging to the III-biological position is 3.59 m. With the growth of the trees and the increase in their diameter degree, there is a distinct trend of higher differentiation in the value of the absolute crown length due to which trees of the I-biological position are increasingly separated from those of the second, whereas trees of the third biological position, due to decreased space and the expansion of trees of the first and second biological position are increasingly lagging behind in terms of the development of their crowns.

The confirmed values of the absolute crown length of the Douglass fir trees are lower in comparison with the so far confirmed values of the absolute crown length and ranged from 9.53 to 15.51 m for the fir on the Maleshevski mountains (Velkovski 2007), 9.20 to 12.00 m for the fir on Kozhuv (Ristevski 1984), 7.00 to 13.80 m for the fir on the Osogovski mountains (Ivanovski 1978), 7.00 to 14.80 m for the mixed plantations of fir and black pine in the Eastern forest region of Macedonia (Trajkov 1997), and 12.68 to 20.88 m for the sequoia trees on Karadjica mountain (Delov et al.) 2014). The measured values of the absolute crown length of the Douglass trees are higher in comparison with those of the Serbian spruce in the seed plantation of the region of Srebrenica, measuring 5.00 m for the trees of the I-biological position, 4.20 m for the trees of the II-biological position and 3.15 m for the trees of the III-biological position. (Krstić et al., 2016).

The relative crown length is obtained as the ratio between the absolute crown length of the tree and its total height. It shows how much of the total height of the tree is assumed by the crown of the tree, i.e. how much of the total height of the tree spreads out into branches.

Table IV: Relative crown length, classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Relative crown lengthin percentage						
I			26.32	28.13	35.71	36.26	31.61
II		21.97	24.18	26.83	28.90	32.10	26.80
III	12.24	17.91	22.01	23.08	24.17		19.88

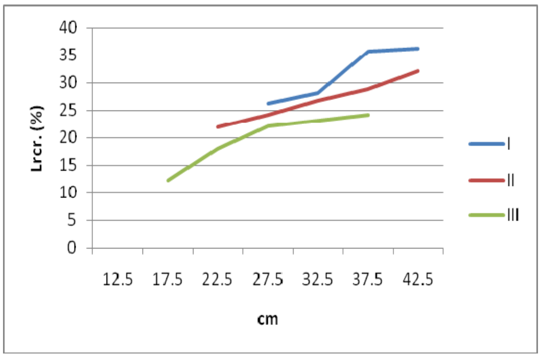

Figure 5: Relative crown length

The results on the relative crown length listed in table IV and graphically illustrated in Fig.5 shows that with the increase in their size, the relative crown length of all trees has also increased, regardless of their biological position. The trees of the I-biological position have the highest relative crown length, which ranges from 26.32% with a diameter degree of 27.5 cm and 36.26% with a diameter degree of 42.5 cm. The average relative crown length of the trees of the first biological position is 31.61%. The relative crown length of the trees of the second biological position ranges from 21.97% with a diameter degree of 22.5 cm to 32.10% with a diameter degree of 42.5 cm. The mean relative crown length of the trees of the second biological position is 26.80%. The thinnest trees of the III-biological position have the lowest relative crown length of 12.24% with a diameter degree of 17.5 cm ranging up to 24.17% with a diameter degree of 37.5 cm. The relative crown length of the trees of the III-biological position is 19.88%.

The confirmed average values of the relative crown length of the Douglass trees are lower in comparison with the so far confirmed values of the relative crown length and range from 36.46 to 63.36% for the fir on the Maleshevski mountains (Velkovski 2007), 27.70 to 42.00% for the fir on Kozhuv (Ivanovski 1978), 9.00 to 57.00% for the combined fir and black pine plantations in the Eastern forest region of Macedonia (Trajkov 1997) and 57.38 to 70.97% for the sequoia on Karadjica mountain (Delov et al. 2014). Krstić et al. (2016)

established that the relative crown length of the Serbian spruce seed plantations ranged from 19 to 64% or an average of 36.5% for the trees of the I-biological position, 23 to 57% or an average of 35.7% for the trees of the II-biological position, and 24 to 46% or an average of 33.0% for the trees of the III-biological position.

The horizontal crown projection has been measured mathematically and is in direct correlation with the size of the average crown diameter. It is the surface covered by the tree crown.

Table V: Horizontal crown projection, classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Horizontal crown projection in m²						
I			17.79	26.41	30.08	33.57	26.96
II		13.59	17.86	25.95	26.59	29.30	22.66
III	6.70	11.70	12.87	20.90	26.05		15.64

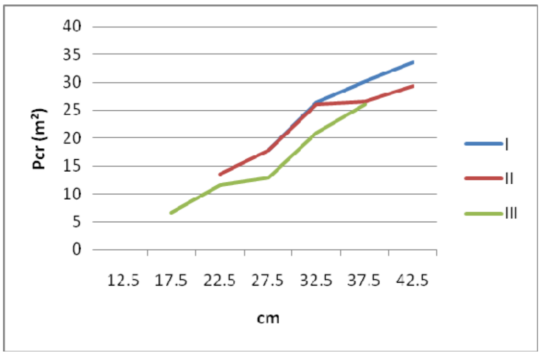

Figure 6: Horizontal crown projection

The results on the horizontal crown projection stated in table V and graphically illustrated in Fig.6 shows that all trees, regardless of their biological position, mark a trend of increase in the size of their horizontal projection by increasing their diameter degree. The largest i.e. the dominant trees have the largest horizontal crown projections. The trees of the III-biological position have the smallest horizontal crown projection, because due to their biological position in the plantation they are suppressed trees and haven't succeeded in growing larger diameters and developing their crowns, in comparison with the co-dominant and more dominant trees. The trees of the I-biological position have the largest horizontal crown projection of 33.57 m² with a diameter degree of 42.5 cm, where as the thinnest trees of the III-biological position have the smallest horizontal projection of 6.70 m² and are of diameter 1. The average mean value of the horizontal crown projection measures 26.96 m² for the trees of the I-biological position, 22.66 m² for the trees of the II-biological position, and 15.64 m² for the trees of the III-biological position.

The mean values of the horizontal crown projection of the Douglass fir trees are within the limits of the so far confirmed values of the horizontal projections of the trees. The horizontal projection ranged from 23.77 to 54.95 m² for the fir on the Maleshevski mountains (Velkovski 2007), 25.00 to 35.00 m² for the fir on Kozhuv (Ristevski 1984), 10.70 to 33.80 m² for the fir on the Osogovski mountains (Ivanovski 1978), 15.50 to 38.20 m² for the fir on Rudnik (Panikj 1966), 9.00 to 64.00 m² for the mixed plantations of fir and black pine in the Eastern forest region of Macedonia (Trajkov 1997), and 13.06 to 33.81 m2 for the sequoia on Karadzica mountain (Delov et al. 2014).

The crown diameter index is obtained as the ratio between the length of the tree crown and the length of the crown.

Table VI: Crown index, classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Crown index						
I			1.05	1.03	1.21	1.26	1.14
II		0.92	0.92	0.96	1.07	1.06	0.99
III	0.34	0.93	0.99	0.87	0.84		0.79

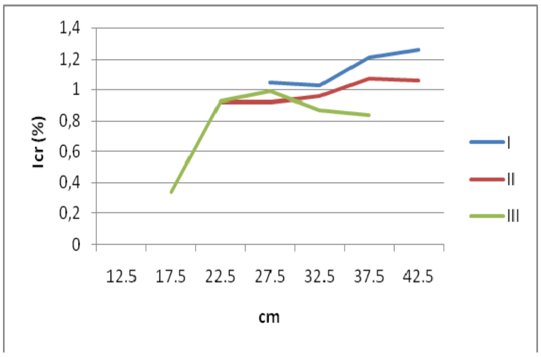

Figure 7: Crown Index

The data stated in table VI and Fig.7 shows that the trees of the I-biological position which are dominant on the plantation have the highest values of the crown index. The average value of the crown index is 1.14 for the trees of the III-biological position, 0.99 for the trees of the II-biological position and 0.79 for the trees of the I-biological position. This state results from the dominant trees of the I-biological position having increased their height and still not having had their crown cleared of branches, due to which they are characterized by quite long crowns, the diameter of which they couldn't expand due to the density of trees on the plantation.

The mean values of the crown index of the Douglass fir trees are lower in comparison with the so far confirmed values of their crown index and ranged from 1.28 to 2.55 for the fir on the Maleshevski mountains (Velkovski 2007), 2.10 to 2.30 for the fir on Kozhuv (Ristevski 1984), 1.28 to 2.72 for the fir on the Osogovski mountains (Ivanovski 1978), 1.50 to 2.24 for the fir on Rudnik (Panić 1966) and 3.07 to 3.51 for the sequoia on Karadzica mountain (Delov et al. 2014).

The lower values of the crown index for the Douglass trees are due to the increased number of trees per unit area, as well as due to not implementing tending techniques which results in the trees not having enough space for further development of their crowns.

The coefficient of space for growth is obtained as the ratio between the crown diameter and the front diameter of trees measured from breast height.

The results on the ratio between the crown diameter and the front diameter of the trees stated in table VII and graphically illustrated in Fig. 8 shows that the trees of the I-biological position have the highest coefficient of space for growth in the plantation.

ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

Table VII: Growing space coefficient, classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Growing space coefficient						
I			17.31	17.85	16.51	15.39	16.77
II		18.49	17.45	17.69	15.52	14.38	16.71
III	16.69	17.16	14.73	15.88	15.36		15.96

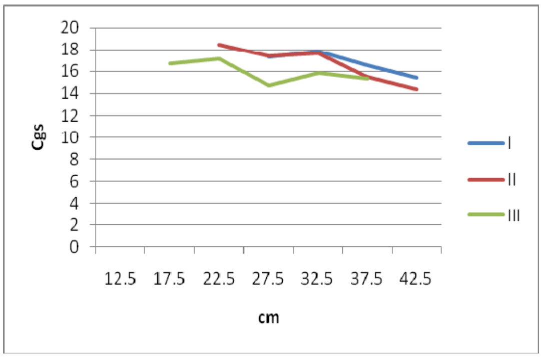

Figure 8: Growing space coefficient (quotient of crown expansion)

The average mean value for the coefficient of space for growth is 16.77 for the trees of the I-biological position, 16.71 for the trees of the II-biological position, and 15.96 for the trees of the III-biological position. These values, as well as the trend of decrease in the values of the coefficient of space for growth indicate that the trees in the plantation already used up the maximum space for growth which they had at their disposal, although the diameter of the front height of the trees is on the increase. The coefficient of space for growth has a huge impact on the increase in the diameter and can be regulated by thinned cuttings of appropriate intensity (Krstić 2003). The average values of the coefficient of space for crown growth ranged from 17.89 to 28.02 for the fir trees on the Maleshevski mountains (Velkovski 2007), 15.76 to 20.93 for the fir on Kozhuv (Ristevski 1984), 11.50 to 17.40 for the fir on the Osogovski mountains (Ivanovski 1978), 12.00 to 15.00 for the fir on Rudnik (Panić 1966), 8.39 to 9.17 for the sequoia on Karadjica mountain (Delov et al. 2014), 28.50 to 38.50 for the low trunk fir plantations on Mavrovo (Krstevski 1975). The crown expansion coefficient for the Serbian spruce trees in the seed plantations of the region of Srebrenica ranged from 5.83 to 16.3 or an average of 10.07 for the trees of the I-biological position. It ranged from 6.56 to 13.2 or an average of 10.13 for the trees of the II-biological position, where as it ranged between 9.0 and 11.8 or an average of 10.20 for the trees of the III-biological position (Krstić at al. 2016).

The relative space for tree growth is obtained as the ratio between the diameter (width) of the crown and the total height of the tree.

The data stated in table VIII and Fig. 9 shows that the relative space for growth of the trees of the I-biological position ranges from 0.25 to 0.29 or an average of 0.28. This value ranges from 0.24 to 0.30 or an average of 0.27 for the trees of the second biological position, and 0.19 to 0.36 or an average of 0.26 for the tress of the third biological position.

Table VIII: Relative space for tree growth, classes and biological positions (CBP)

CBP	diameter degrees (cm)						
	17.5	22.5	27.5	32.5	37.5	42.5	Mean
	Relative space for tree growth						
I			0.25	0.27	0.29	0.29	0.28
II		0.24	0.26	0.28	0.27	0.30	0.27
III	0.36	0.19	0.22	0.26	0.29		0.26

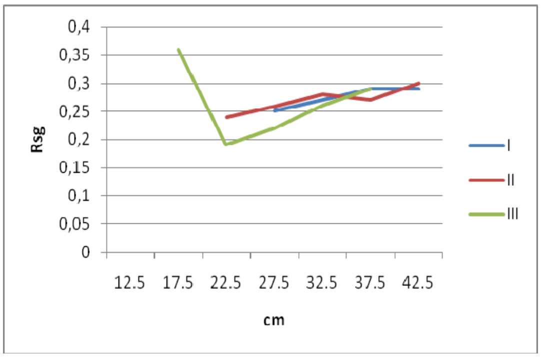

Figure 9: Relative space for tree growth per diameter degrees

The confirmed average values for the relative space for crown growth of the Douglass fir trees are within the limits of the so far confirmed values. The average values for the relative space for growth ranged from 0.23 to 0.36 for the fir on the Maleshevski mountains (Velkovski 2007), 0.19 to 0.28 for the fir on Kozhuv (Ristevski 1984), 0.14 to 0.22 for the fir on the Osogovski mountains (Ivanovski 1978), 0.19 to 0.22 for the sequoia on Karadzica mountain (Delov et al. 2014), and an average of 0.33 for the fir forests on Rudnik (Panić 1966). The relative space for growth for the Serbian spruce trees in the seed plantations of the region of Srebrenica for the trees of the I-biological position ranged from 0.17 to 0.64 or an average of 0.35. This figure ranged from 0.21 to 0.63 or an average of 0.37 for the trees of the II-biological position, and 0.3 to 0.41 or an average of 0.37 for the trees of the III-biological position (Krstić at al. 2016).

4 CONCLUSIONS

On the basis of the results from the research and study of certain elements characterizing the crowns of the Douglass fir (*Pseudotsuga menziesii* (Mirb.) Franco) trees on Karadzica mountain, the following may be concluded:

1. The dominant trees of the I-biological position in the plantation succeeded in developing the largest crowns in comparison with the trees of other positions. The average mean crown diameter measures 5.82 m for the trees of the I-biological position, 5.32 m for the trees of the II-biological position, and 4.35 m for the trees of the III-biological position.

2. With the increase in their size, the absolute crown length of all trees has also increased, regardless of their biological position, which is most noticeable in the dominant trees and least in the suppressed trees. The trend of the trees of the III-biological position lagging behind in the development of their crowns is present due to the dominant and co-dominant trees already

suppressing the trees of the III-biological position in the plantations. The average mean value for the absolute crown length measures 6.69 m for the trees of the I-biological position, 5.30 m for the trees of the II-biological position, and 3.59 m for the trees of the III-biological position.

3. The relative crown length of the dominant trees stands at 32 % of their total height, 27 % for the co-dominant trees, and 20 % for the suppressed trees.

4. The trees of the I-biological position with a diameter degree of 42.5 cm have the largest horizontal crown projection of 42.5 m², whereas the thinnest trees of the III-biological position with a diameter degree of 17.5 cm have the lowest relative crown length of 6.70 m². The average mean horizontal crown projection measures 26.96 m² for the trees of the I-biological position, 22.66 m² for the trees of the II-biological position, and 15.64 m² for the trees of the III-biological position.

5. The average mean value of the crown index is 1.14 for the trees of the I-biological position, 0.99 for the trees of the II-biological position and 0.79 for the trees of the III-biological position. This is a result of the dominant trees of the I-biological position having increased their height and still not having had their crown cleared of branches, due to which they are characterized by quite long crowns, whereas because of the existing density of trees in the plantation they still haven't achieved larger dimensions of the crown diameter. The high values of the crown index for the Douglass fir clearly indicate greater predisposition for larger development of the crown in length instead of in width.

6. The average mean values of the coefficient of space for growth is 16.77 for the trees of the I-biological position, 16.71 for the trees of the II-biological position, and 15.96 for the trees of the III-biological position. These values, as well as the trend of decrease in the values of the coefficient of space for tree growth indicate that the trees have already used up the maximum space for growth which they had at their disposal, although the front height diameter of the trees is on the increase.

7. The average mean value of the relative space for growth is 0.28 for the trees of the I-biological position, 0.27 for trees of II-biological position, and 0.26 for trees of III-biological position.

8. For the purpose of improving the condition of the plantations and directing their development in an optimal direction, execution of thinned cuttings is needed in order to regulate the number of trees per unit area, as well as their spatial distribution in the plantation with the purpose of achieving better use of the space for the development of trees in the plantation.

5 REFERENCES

[1] Andonovski, A., (1978): Introduction of exotic species-important element of the subject matter of cultivation of forest tree types, including a review ofpast experiences and possibilities in SR Macedonia. Annual Reviewof the Faculty of Forestry in Skopje. Book 28, p. 59-67. Skopje.

[2] Delov, K., Velkovski, N., Vasilevski, K. (2014): Studing of particular elements which characterize *Sequoiadendron giganteum* (Lindl.) Buchholz trees on Karadzica Mountain. Forest review 45:9-16. Skopje, 2014.

[3] Delov, K., (2016): Research on the effects from the application of ameliorative and tending measures on the northern slopes of Jakupica mountain, (Doctor's dissertation), UKIM Faculty of Forestry-Skopje.

[4] Dzekov, S. (1988): Dendrology, University „Cyril and Methodius" – Skopje, Skopje.

[5] Ivanovski, C., (1978): Structure and productivity of the homogenous fir plantation of a jungle type on the Osogovski mountains (Doctor's dissertation), UKIM Faculty of Forestry-Skopje.

[6] Krstevski, K., (1975): Study on the characteristics of crowns in low trunk fir plantations (Master's dissertation), Faculty of Forestry-Belgrade.

[7] Krstić, M. (2003):The sessile oak forests of the Djerdap region:condition and tending measures. Akademska misao. Belgrade. P. 1-136.

[8] Krstić, M., Stojanovich, Lj. (2007): Tending sessile oak forests. Monography: The sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) in Serbia. UITS,University in Belgrade-Faculty of Forestry Belgrade, p. 209-292..

[9] Krstić, M., Stavretović, N.,Isajev, V., Bjelanović, I. (2013): Crown structure of *Picea omorica* trees in the plantation. Arch. Biol. Sci. Belgrade 65 pg. 621-629.

[10] Krstić, M., Kanjevac, B., Bojić, S. (2016): Serbian spruse (*Picea omorica* Panč./Purkyne) crown structure in a seed stand in the area of Srebrenica. Forestry 1-2, Beograd, pg.39-52.

[11] Larson, B., (2010): The dynamicis of Douglas-fir stands. U:H. Spiecker, U. Kohnle, K. Makkonen-Spiecker, K. Von Teuffel, Opportunities and risks for Douglas fir in a changing climate, Forstliche Versuchs-und Forschungsanstalt baden-Wurttemberg, IX, Freiburg.

[12] Mirchevski, S., Vasilevski, K. (2000): Comparative characteristics of the effects from the introduction of black pine, Scots pine, white pine and other species in degraded forests and bare areas in the Republic of Macedonia. Jubilee Annual Miscellany of the Faculty of Forestry-Skopje, p. 53-64, Skopje

[13] Panić, GJ., (1966): The impact of the biological position of trees and the structure of their crowns and productivity of the fir plantations on Rudnik. Miscellany of the Institute for Forestry and Wood Industry SRS, book 26 Belgrade.

[14] Perić, S., Tijardović, M., Jazbec, A. (2011): Rezultati istraživanja provenijencije zelene duglazije u ekološki različitim područjima kontinentalne Hrvatske. Šumarski list-Posebni broj (2001), 190-201. Zagreb

[15] Ristevski, P., (1984): Structural elements and productivity of the fir plantations on Kozhuv mountain (Master's dissertation), UKIM Faculty of Forestry-Skopje.

[16] Ristevski, P., (1987): Condition, productivity and influence of certain elements of the crown over the productivity of the black pine plantations in the region of the Maleshevski mountains (Doctor's dissertation), UKIM Faculty of Forestry-Skopje.

[17] Stojanovich, Lj., Krstić, M. (2008): Gajenje šuma I. Univerzitet u Beogradu-Šumarski fakultet, Beograd.

[18] Velkovski, N., (2007): Bioecological characteristics and natural regeneration of the fir forests on the Maleshevski mountains, (Doctor's dissertation), UKIM Faculty of Forestry-Skopje.

ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

[19] Velkovski, N., Vasilevski, K., Delov, K. (2012): Development ofthe *SEQUOIADENDRON GIGANTEUM* (LINDL.) BUCHHOLZ), *PSEUDOTSUGA MENSIESII* (MIRB.) FRANCO) and *PINUS STROBUS* (L.) trees introduced in the region of the sessile oak on Karadjica mountain. Miscellany of works, Banja Luka, Republic of Serbia, B&H.






ШУМАРСКИ ПРЕГЛЕД	**FOREST REVIEW**
Меѓународно научно списание	International Scientific Journal
Год. 47, бр. 1 / Стр. 1-47	Vol. 47, No. 1 / Pag. 1-47
Скопје, 2016	Skopje, 2016
Online ISSN 1857-9507	Online ISSN 1857-9507
УДК 630	UDC 630
УДК 635.9	UDC 635.9
УДК 674	UDC 674
Издавач	**Publisher**
Универзитет „Св. Кирил и Методиј“ во Скопје	Ss. Cyril and Methodius University in Skopje
Шумарски факултет во Скопје	Faculty of Forestry in Skopje
в. д. Декан	Acting Dean
Д-р Кирил Сотировски	Kiril Sotirovski PhD

Излегува два пати годишно	Published twice a year
Интернет-страница	**Web page (on-line)**
www.sf.ukim.edu.mk/sumarski_pregled.htm	www.sf.ukim.edu.mk/sumarski_pregled.htm
Адреса на издавачот	**Publisher's address**
УКИМ-Шумарски факултет во Скопје	UKiM Faculty of Forestry in Skopje
Редакција на Шумарски преглед	Editorial Board of the Forest Review
Ул. „16 Македонска бригада“ бр. 1	Ul. 16 Makedonska brigada br. 1
(П. фах 235)	(P.O. box 235)
1 000 Скопје	MK-1000 Skopje
Република Македонија	Republic of Macedonia
Е-пошта: sumpregled@sf.ukim.edu.mk	E-mail: sumpregled@sf.ukim.edu.mk
www.sf.ukim.edu.mk	www.sf.ukim.edu.mk