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FOREST REVIEW

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CONTENTS

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STUDYING OF PARTICULAR ELEMENTS WHICH CHARACTERIZE *SEQUOIADENDRON GIGANTEUM* (LINDL.) BUCHHOLZ TREES ON KARADZICA MOUNTAIN

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ABSTRACT: This paper shows the results from the researches and studies of particular elements which characterize the crown of *Sequoiadendron giganteum* (Lindl.) Buchholz trees on the Karadzica Mountain. The Sequoia tree was introduced in 1965, in the area of the *Quercus petraea* and throughout its 50-year growthit has shown very good adaptability and productivity, which exceeds all other introduced non-indigenous types of trees, as well as the other indigenous types of trees. Having in mind that the crown of the Sequoia trees on Karadzica Mountain has never been studied, this paper contains information on the researches made on its structural elements,which have been processed mathematically and statistically and produces information on the main structural elements which characterize the crown. The results obtained from the conducted researches show that Sequoiatrees form properly developed cone-shaped crowns. The crowns are characterized with higher vertical length and a high share of the crown in the total height of the tree, varying between 57 % at the suppressed trees, 65 % at the codominant trees and 71 % at the dominant trees. The horizontal projection of the crowns is varying between 33.81 m^2 and 13.06 m^2. Crown index valuesfor the Sequoia tree point out that it has higher predispositions for a greater development of the crown in height than in width. The established average mean coefficient values for the growth of the crowns point out that the Sequoiahas lower coefficients and lower capability to overrun the space in width. The average mean values for the relative growth space point out that theSequoiauses more space for growth in height than in width.
Keywords: crown, introduction, Sequoia tree (*Sequoiadendron giganteum* /Lindl./ Buchholz).

1 INTRODUCTION

In the literature, *S. giganteum* (Lindl.) Buch. is described as one of the largest and longest living trees. It can reach heights over 100m, a diameter up to 12m and age of around 4000 years. The natural growth area of Sequoiais middle California, in the west slopes of Sierra Nevada, at altitudes between 1500 and 2500m. The first samples of Sequoia in Europe were planted in 1853 in Scotland, and later in Germany, England, Austria etc. It is a very decorative and adaptable type of tree, and it is grown in Europe as a park tree or in small-scaled forests, (Jurković et al. 1996).

S. giganteum (Lindl.) Buchholz was introduced in the Republic of Macedonia in 1958 as park tree, and the first seedlings were produced in 1962 in the tree nursery "Kitka" from seeds obtained from USA. Sequoia trees was planted in the studied area of the Karadzica Mountain, i.e. in Vrteshka area in 1965.

Many authors have studied the results from the introduction of coniferous trees in the Republic of Macedonia, as well as the elements that characterize the crowns of the trees: Andonovski, 1978; Ivanovski, 1978; Panić, 1981; Ristevski, 1984 & 1987; Trajkov, 1992; Velkovski, 1999 & 2007; Mirchevski & Vasilevski, 2000; Acevski *et al.*, 2000; Velkovski *et al.*, 2012 etc.

The researches of Sequoia in Macedonia have shown that this species is much more adaptable and it is characterized with a higher productive capability than the other introduced species, such as *Pseudotsuga mensiesii* (Mirb.) Franco), *Pinus strobus* (L.), *Chamaecyparis lawsoniana* (Parl.), *Larix decidua* (Mill.) and *Larix europaea* (DC.), as well as the other indigenous types of trees *Fagus moesiaca* (Domin, Maly) Chezzot and *Quercus petraea* (Matt.) Liebl. (Velkovski *et al.*, 2012).

The crown of the trees is one of the main factors for growth of each individual tree, and thus, the growth of the forest plantations. The term crown refers to the upper part of the tree, covered with branches, twigs and the main foliage, without sprouts which might appear along the length of the trunk. The crowns of high importance since the entire assimilation apparatus of the tree is located therein and it is the place where the most important physiological processes that influence the growth of the tree take place.

It can be seen from the previous studies of the crowns at various trees and in various areas that the parts of the crown might be in various sizes, as well as the correlations among them. Such differences can be found among different types of trees, as well as among different conditions for growth and development. The shape and the development of the crown depend on multiple factors, such as the age of the tree, its location in the plantation, the exposure to wind, as well as other biotic and abiotic factors. One of the most important factors that affect the development of the crown is the sunlight. The trees which are exposed to direct sunlight from all sides, and which grow on open space, develop crowns with greater dimensions. The share of the crown in the total height of these trees can be large, i.e. often larger than ½, or even larger than ¾ of the total height of the tree. The trees that receive direct sunlight only from the upper side, and those are the trees that grow in a dense surrounding of plantations, have smaller crowns and branch-free trunks, and the share of the crown is lower than 1/3 of the total height of the tree. The sunlight is a factor that can contribute towards larger asymmetry of the tree crown, by forming one-sided and asymmetric crowns with higher exposure towards the inflow of sunlight.

2 INVESTIGATION AREA AND METHOD

In 2014, measurements have been conducted for the elements characterizing the crown of the trees. The measurements covered 67 Sequoia trees spread throughout an area of 0,2 ha in the region of Kitka Mountain. The measurements have determined the diameters of breast height for each tree separately, as well as the height of all trees, the absolute crown length, the radii of the crown towards the four cardinal points,

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the biological position of the trees as well as the quality structure of the crown. All investigated trees have been recorded in accordance with their position in the plantation, and their coordinates have been determined by means of GPS device. Some elements of the crown can be completely different and can be measured directly (width, length), while other can be obtained as a relation between the measured elements which are important for various studies of the tree or the plantation (Velkovski 2007). The obtained results are grouped into levels according to the thickness and divided according to the biological position of the trees into tree classes, whereby the I class covers the dominant trees in the plantation, II class covers the codominant trees, while the III class covers the suppressed trees. Based on the collected data and the mathematical and statistical calculations and analyses, the following has been determined: the mean diameter of the crowns, the horizontal projection of the crowns, the relative length of the crowns, the crown index, the growth space coefficient and the relative growth space of the tree. The obtained results are given in tables and figures, and based on the analyses and calculations, the following conclusions have been made.

The plantation with Sequoia trees, which is a research object of this paper, is located on the Karadzica Mountain, in the central area of the Republic of Macedonia, on the western side of the river Vardar. The studied area belongs to the cold continental area in the Republic of Macedonia, where the climatic and zonal association *Orno-Quercetum petraeae* Em (forest association of the *Quercus petraea)* prevails and covers relatively narrow height zone in the Republic of Macedonia of 200 m, i.e. the altitude from 900 to 1000 m. In some colder areas, *Quercus petraea* Liebl. goes down to 600 m (in the zone of *Quercus frainetto* Ten.), while in the warmer zones, it raises up to the zone of ***ass.*** *Festuco heterophyllae-Fagetum* Em up to the altitude of 1300 m (Velkovski ***et al.***, 2012).

Cold continental climate prevails in the studied area, with some influence from the Alpine climate. The annual mean temperature, calculated according to the vertical gradient curves for this area, varies between 8.6 and 9.6 °C, i.e. 9° C in average. The absolute maximum was 49°C, while the absolute minimum was -19.9°C. The average precipitation was 900 to 940 mm. The geological basis consists of silicate and the soils are eutric cambisoles (brown forest soils) with medium depth, reach in humus and fallen leaves. In general, the natural conditions in the studied area have shown to be favorable for the development of the Sequoia trees.

3 RESULTS AND DISCUSSION

Previous research of the crowns have determined great differences in the elements that characterize the crowns, depending on the location of the trees, availability of sunlight to the crown, age of the tree, growing site, undertaken silvicultural and regeneration measures, suitability of the location for growth, biological position of the trees, plantation characteristics etc.

The external profile of the trees to a great extent depends on the correlation or proportion of the trunk and the crown, which are the basic elements of each tree.

The plantation with Sequoia trees (Fig. 1 and Fig. 2) grows in favorable natural conditions and has appropriately developed crowns (Fig. 3 and Fig. 4).

Figure 1, 2: *Sequoiadendron giganteum* plantations at the investigation area

Figure 3, 4: Development of the crowns of ***S. giganteum*** trees at the investigation area

The crown diameter, constituting its widest part, has been determined on the basis of the measured radii towards the four cardinal points. Larger crown diameters mean larger crown development.

Figure 5: Development of the crowns of *S. giganteum*

The results for the mean crown diameter of Sequoia trees, divided by thickness degrees and classes of biological position, are given in Table I and graphically shown in Fig. 6.

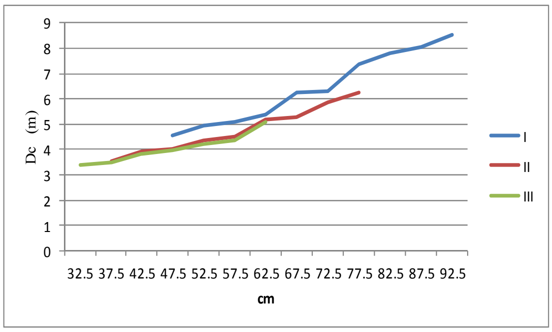

Figure 6: Mean crown diameter

It can be seen from the results for the crown diameters, given in Table I and graphically shown in Fig. 6 that the crown diameter increases proportionally with the thickness diameter, at all trees, regardless of their biological position. The most dominant trees have largest crown diameters at all thickness degrees. The trees of III biological class have the smallest diameters as they are suppressed trees in accordance with their biological position in the plantation, and did not manage to produce larger diameters and develop their crown, as the case is with codominant and dominant trees. However, the difference in crown diameters of the trees from II and III biological class is not too significant, which points out to the uneven development of the crown diameters at these two classes of trees. Largest mean crown diameter has noticed at the trees from I biological class, which belong to the thickness degree 92.5 cm, where the mean diameter is amounting to 8.52 m, while lowest crown diameter has been noticed atthe thinnest trees of III biological class, which belong to the first thickness degree 32.5 cm, where the mean diameter is amounting to 3.39 m. The average mean value of the mean crown diameter is 6.42 m for the trees of I biological class, 4.77 m for the trees of II biological class, and 4.04 m for the trees of III biological class.

The mean crown diameter values for the Sequoia trees are lower when compared to the determined mean diameter values for the beech trees at Maleshevo Mountains, ranging from 5.46 to 8.56 m (Velkovski 2007), the beech trees at Kozuf, ranging from 6.00 to 6.80 m (Ristevski 1984), the beech trees at Osogovo Mountains, ranging from 5.00 m to 6.90 m (Ivanovski 1978), from the beech trees at Rudnik, ranging from 4.4 to 7.0 (Panić 1966), as well as the mixed plantations of beech and black pine in the Eastern forest region of Macedonia, ranging from 3.4 to 9.0 m (Trajkov 1997).

The absolute crown length is obtained as a difference from the total height of the tree and the length of the trunk. It is one of the main elements that affect the total growth of the tree.

The results for the absolute crown width of Sequoia trees are divided into thickness degrees and classes of biological position, and given in Table II, as well as graphically shown in Fig. 9.

It can be seen from the results for the absolute crown length, given in Table II, and graphically shown in Fig. 9, that the absolute crown length at all trees increases with the growth of the tree, regardless of their biological position. The crowns are the largest at trees of I class, which prevail in the plantation, while trees of II and III classes (codominant and suppressed) are somewhat identical up to the thickness degree of 47.5 cm. Codominant trees clearly distinguish themselves by their crowns with greater absolute lengths formed at the higher thickness degrees.

The development of the crowns for the trees of III class of biological position is lagging) because the dominant and codominant trees suppress the trees of the third biological position.

The trees of I biological class with thickness degree of 92.5 cm have greatest absolute crown length, amounting to 23.20 m, while the thinnest trees of III biological class with thickness degree of 32.5 cm have lowest absolute crown length, amounting to 5.00 m.The average values of the absolute crown length for the trees of I biological position are amounting to 20.88, 16.82 m for trees of II biological position, and 12.68 m for trees of III biological position.

The determined average values of absolute crown lengths of Sequoia trees are higher when compared to the determined values of absolute crown lengths of the beech trees on Maleshevo Mountains, ranging from 9.53 to 15.51 m (Velkovski 2007), the beech on Kozuf, ranging

Table I: Mean crown diameter

Biological position (class)	Thickness degree													
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Mean
	Mean diameter in meters													
I				4.55	4.93	5.08	5.38	6.23	6.30	7.35	7.82	8.04	8.52	6.42
II		3.54	3.93	4.02	4.35	4.49	5.16	5.30	5.85	6.25				4.77
III	3.39	3.48	3.84	3.98	4.20	4.34	5.08							4.04

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from 9.20 to 12.00 m (Ristevski 1984), the beech on Osogovo Mountains, ranging from 7.00 m to 13.80 m (Ivanovski 1978), as well as the mixed plantations of beech and black pine in the Eastern forest region of Macedonia, ranging from 7.0 to 14.80 m (Trajkov 1997).

Figure 7, 8: Crown length of *Sequoiadendron giganteum*

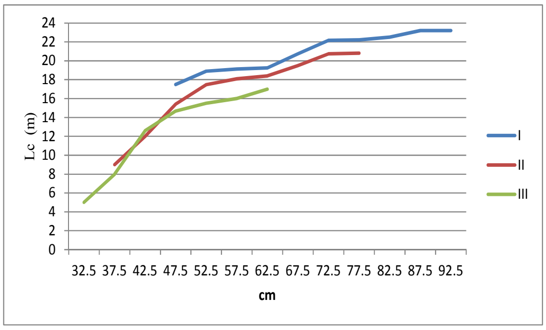

Figure 9: Absolute crown length

This situation is due to the genetic features of Sequoia tree, which forms dense and cone-shaped crown, as well as due to the fact that the trees have not started yet with more intensive fremoval of branches. Another important segment is the position in the plantation, whereby the number of trees per unit area is still not too high in order to contribute towards more intensive removal of the branches from the crown.

The relative crown length is obtained as a relation between the absolute crown length and the total height of the tree. This shows the share of the tree crown in the total height of the tree, i.e. what part of the total height of the tree has grown branches.

It can be seen fromthe data in Table III and Fig. 10 that the relative crown length has quite high values for all trees, regardless of their biological position. The mean value for the relative crown length for the trees of the first biological class is amounting to 70.97, 65.51 for the trees of the second biological position and 57.38 for the trees of the third biological class. This means that the crown of the dominant trees covers 71% of the total height, 65% at codominant trees and 57% at the suppressed trees. Such a high share of the crown in the total height of the Sequoia trees is normal as it has quite composed and cone-shaped crown in accordance with its genetic features, meaning that the removal of branches takes place at a later stage.

The determined average values for the relative crown length of Sequoia trees are higher when compared to the determined values for the relative crown lengths at the beech trees on Maleshevo Mountains, ranging from 36.46 to 63.36% (Velkovski 2007), the beech on Kozuf, ranging from 41.13 to 55.81% (Ristevski 1984), the beech treeson Osogovo Mountains, ranging from 27.70 to 42.00 (Ivanovski 1978), as well as the mixed plantations of beech and black pine in the Eastern forest region of Macedonia, ranging from 9.00 to 57.00 (Trajkov 1997).

The horizontal projection of crowns is obtained mathematically and it is directly dependent on the height of the crown's mean diameter. It is constituted by the area covered by the crown of the tree.

The results of the horizontal crown projection set out in Table IV and shown graphically in Fig. 11 indicate that in all trees, in whatever biological class found, there is a trend of increased horizontal projection by increasing the degree of thickness. The biggest i.e. dominant trees also have the largest horizontal crown projections in all degrees of thickness. There is the lowest horizontal crown projection of trees in the III biological class, because in accordance with their biological position in the plantation, they are suppressed trees and have failed to achieve larger diameters and develop their crowns, as the codominant and dominant trees. However, the differences in the horizontal crown projection of trees in the II and III biological position is not very high indicating a more equal development of the crown diameter of the trees from these two classes. There is the biggest horizontal crown projection of the trees in the I biological class found in the thickness degree of 92.5 cm, which is 56.98 m², and there is the lowest horizontal projection of 9.02 m² in the thinnest trees of the III biological class, found in the first degree of thickness.

Table II: Absolute crown length

Biological position (class)	Thickness degrees												
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Mean
	Absolute length in meters													
I				17.50	18.90	19.13	19.25	20.75	22.17	22.20	22.50	23.20	23.20	20.88
II		9.00	12.00	15.40	17.47	18.10	18.40	19.50	20.75	20.80				16.82
III	5.00	8.00	12.60	14.67	15.50	16.00	17.00							12.68

Table III: Relative crown length

Biological position (class)	Thickness degrees													
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Mean
	Relative crown length in percentage													
I				67.31	72.41	70.20	69.79	72.48	76.00	71.15	69.23	70.84	70.30	70.97
II		42.86	51.06	62.86	72.28	70.07	70.50	72.22	74.77	72.98				65.51
III	25.97	39.51	59.63	65.69	70.45	69.57	70.83							57.38

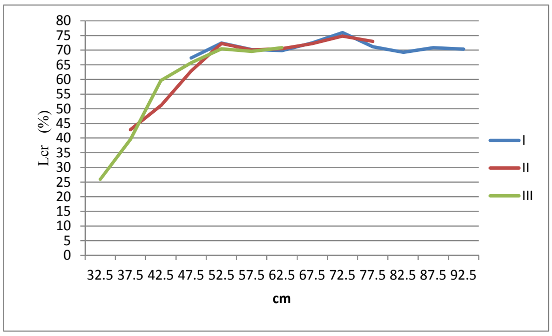

Figure 10: Relative crown length

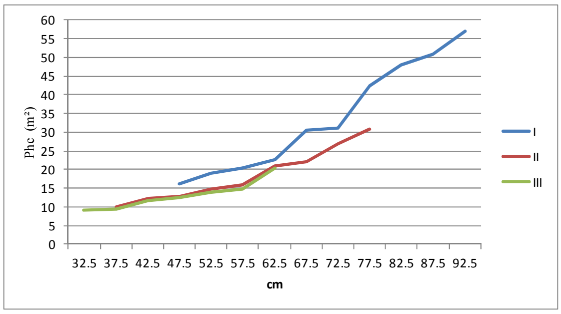

Figure 11: Horizontal crown projection

Table IV: Horizontal crown projection

Bio. Pos. (class)	Thickness degrees													
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Medium
	Horizontal projection in m^2													
I				16.25	19.08	20.26	22.72	30.47	31.16	42.41	48.00	50.74	56.98	33.81
II		9.84	12.12	12.69	14.85	15.83	20.90	22.05	26.86	30.66				18.42
III	9.02	9.51	11.58	12.43	13.85	14.79	20.26							13.06

Table V: Crown index

Bio. Pos. (class)	Thickness degrees													
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Medium
	Crown index													
I				3.85	3.83	3.77	3.58	3.33	3.52	3.02	2.88	2.89	2.72	3.34
II		2.54	3.05	3.83	4.02	4.03	3.57	3.68	3.55	3.33				3.51
III	1.47	2.30	3.28	3.69	3.69	3.69	3.35							3.07

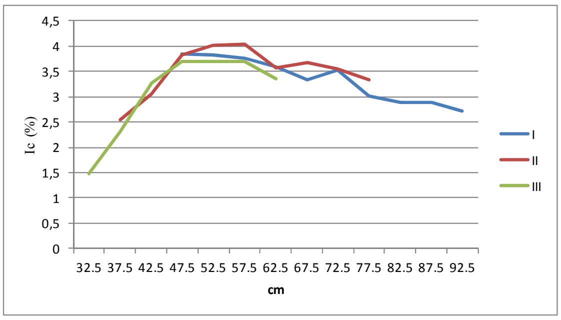

Figure 12: Crown Index

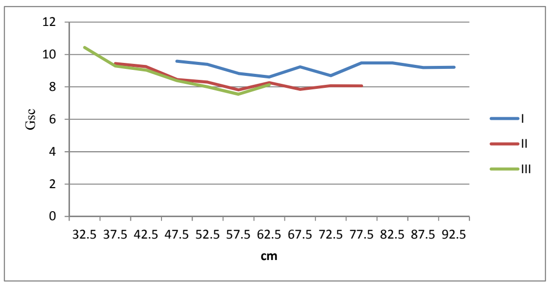

Figure 13: Growing space coefficient (quotient of crown expansion)

Table VI: Growing space coefficient

Bio. Pos. (class)	Thickness degrees													
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Medium
	Ratio between the crown diameter and the trunk diameter at breast height													
I				9.58	9.39	8.83	8.61	9.23	8.69	9.48	9.48	9.19	9.21	9.17
II		9.44	9.25	8.46	8.29	7.81	8.26	7.85	8.07	8.06				8.39
III	10.43	9.28	9.03	8.38	8.00	7.55	8.13							8.69

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Table VII: Relative space for tree growth

Bio. Pos. (class)	Thickness degrees													
	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	Medium
	Ratio between the crown width and the total stem height													
I				0.17	0.19	0.19	0.19	0.22	0.22	0.23	0.24	0.24	0.26	0.22
II		0.17	0.17	0.16	0.18	0.17	0.20	0.20	0.21	0.22				0.19
III	0.18	0.17	0.18	0.18	0.19	0.19	0.21							0.19

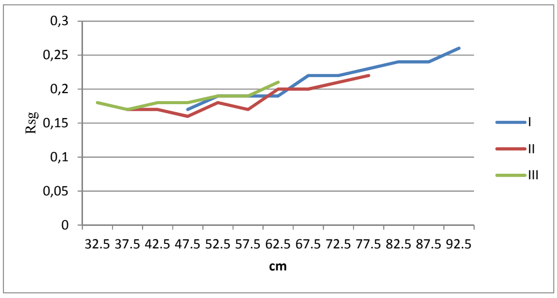

Figure 14: Ratio of the crown width and the total tree height

The average mean value of the horizontal crown projection for trees of the I biological position is 33.81 m², for trees of the II biological position it is 18.42 m², and for trees of the III biological position it is 13.06 m².

The mean values of the horizontal projection of the sequoia crowns are smaller compared to the previously determined values of the horizontal projection in beech trees in the Maleshevo Mountains ranging between 23.77 to 54.95 m² (Velkovski 2006), in beech trees on Kozuv ranging from 25.00 to 35.00 m² (Ristevski 1984), in beech trees in the Osogovo Mountains ranging from 10.70 to 33.80 m² (Ivanovski 1978), in beech trees on Rudnik between 15.50 and 38.20 m² (Panić 1966), as well as mixed plantings of beech and black pine in the Eastern region of Macedonia ranging from 9.00 to 64.00 m² (Trajkov 1997).

The crown index is obtained as the ratio between the length of the tree crown and the crown diameter. It indicates by how many times the crown length is greater than the crown diameter.

The data presented in Table V and Fig. 12 show that the trees of the II biological class in the plantation that are codominant have the highest values for the crown index. The average value for the crown index of the trees in the II biological class is 3.51, for the trees of the I biological position it is 3.34, for the trees of the III biological class it is 3.07. This situation is due to the fact that codominant trees that make up the II biological class have reached greater heights and still have not cleaned up their crowns from branches, due to which they are characterized by fairly long crowns, and because of the current density of trees in the plantation they have not yet achieved larger crown diameter dimensions.

The mean values obtained for the crown index of sequoia trees are higher than the previously determined values for the crown index of beech trees in the Maleshevo Mountains ranging between 1.28 to 2.55 (Velkovski 2006), in beech trees on Kozuv ranging from 2.1 to 2.3 (Ristevski 1984), in beech trees in the Osogovo Mountains ranging from 1.28 to 2.72 (Ivanovski 1978), and beech trees on Rudnik ranging between 1.50 and 2.24 (Panić 1966). The higher values of the crown index of the sequoia in relation to beech trees on different sites clearly indicate that sequoia trees have higher predispositions for greater development of the crown in length than in width.

The growing space coefficient (quotient of crown expansion) is obtained as the ratio between the crown diameter and the tree diameter measured at breast height. This coefficient shows the dependence of crown growth on the trunk thickness and vice versa.

The results on the ratio between the crown diameter and trunk diameter at breast height indicated in Table VI and graphically shown in Fig. 13 show that the trees of the I biological class that are dominant in the plantation have the highest coefficient of growing space. The average mean values of the coefficient of the crown growing space of trees from the I biological class is 9.17, for trees of the II biological class it is 8.39, and for trees of the III biological class it is 8.69.

The established average values for the coefficient of crown growing space of sequoia trees are smaller than the previously determined values for the coefficient of crown growing space of beech trees of the Maleshevo Mountains ranging between 17.89 to 28.02 (Velkovski 2006), of beech trees on Kozuv ranging from 15.76 to 20.93 (Ristevski 1984), of beech trees in the Osogovo Mountains ranging from 11.50 to 17.40 (Ivanovski 1978), of beech trees on Rudnik between 12.00 and 15.00 (Panih 1966), and the low beech plantations in Mavrovo ranging from 28.50 to 38.50 (Krstevski 1975). This situation suggests that sequoia trees have a much lower coefficient and lower ability to occupy space in width unlike beech trees.

The relative space for tree growth is obtained as the ratio between the diameter (width) of the crowns and the total height of the trees. This is used to establish how the tree uses the space, more in width or height and what the relationship is between the width of the crown and the total height of the tree.

The data presented in Table VII and Fig. 14 show that up to a certain age in which trees reach dimensions of breast height in the 52.5 thickness degree, trees of all biological classes use the growing space almost identically. Then, the trees from the I biological class stand apart, which because of their dominance have greater opportunities to use the relative growing space. The average mean value of the relative growing space among trees of the first biological class is 0.22, for trees of the second biological class it is 0.19 and for trees from the third biological class it is 0.19. The above indicates that the sequoia trees with their branches use more growing space in height than width.

The established average values for the relative growing space of the sequoia tree crowns is smaller compared to the formerly established values for the relative growing space of beech crowns in the Maleshevo Mountains ranging between 0.23 to 0.36 (Velkovski 2006), of beech trees on Kozuv ranging from 0.19 to 0.28 (Ristevski 1984), of beech trees in the Osogovo Mountains ranging from 0.14 to 0.22 (Ivanovski 1978), and the beech forests of Rudnik where the relative growing space was averagely 0.33 (Panić 1966).

4 CONCLUSIONS

Based on the results of surveys and studies of some elements that characterize the crown of *S. giganteum* (Lindl.) Buchholz trees on the Karadzica Mountain the following can be concluded.

The dominant trees that make up the I biological position (class) in the plantation have the most developed crowns in relation to trees of other positions. The average mean diameter of the crowns of trees from the I biological class is 6.42 m, for trees of the II biological class it is 4.77 m, and for trees of the III biological position class it is 4.04 m.

With the growth of the tree the absolute length of the crowns in all trees also grew, irrespective of their biological position. The trees of the I biological position (class) which are dominant in the plantation have the biggest crowns, and in trees of the II and III biological class (codominant and suppressed) there is certain equality up to the 47.5 cm thickness degree. Then, codominant trees are clearly separated which in the higher thickness degrees have formed crowns with higher absolute lengths. The trend of lagging behind in the development of crowns in trees of the III biological class occurs because the dominant and codominant trees in the plantation have suppressed the trees from the third biological class. The average mean values for absolute length of tree crowns of the I biological class is 20.88 m, for trees of the II biological class it is 16.82 m, while for trees of the III biological class it is 12,68 m.

The relative crown length has high values in all trees irrespective of the biological position to which they belong. The crown in dominant trees takes up to 71% of the total height, in codominant trees it is 65% and 57% in suppressed trees. Such high percentage of the crown in the total height of sequoia trees is normal since in accordance with its genetic traits it has tight and cone crown form due to which the branches are cleared at a later age.

There is the greatest horizontal projection of the crown in trees of the I biological position (class) found in the thickness degree of 92.5 cm, and it amounts to 56.98 m² and the lowest horizontal projection of 9.02 m² is present in the thinnest trees of the III biological class, located in the first degree of thickness. The average mean horizontal crown projection of trees of the I biological class is 33.81m², in trees of the II biological class it is 18.42 m², and in trees of the III biological class it is 13.06 m².

The average mean value of the crown index in trees of the II biological class is 3.51, in trees of the I biological class it is 3.34 and in the trees of the III biological position (class) it is 3.07. This situation is due to the fact that codominant trees that make up the II biological class have reached greater heights and still have not cleaned up their crown from branches, due to which they are characterized by fairly long crowns, and because of the present density of trees in the plantation they have not achieved larger diameter dimensions of the tree crown. The high values of the crown index in sequoia trees clearly indicate that sequoia trees have more predispositions for greater development of the crown in length than in width.

The average mean values of the coefficient for crown growing space of trees in the I biological position (class) is 9.17, for the trees of the II biological class it is 8.39, and for trees of the III biological class it is 8.69. The established average values of the coefficient for crown growing space of sequoia trees suggest that sequoia trees have lower coefficients and ability to overrun space in width.

The average mean value of the relative growing space of trees of the first biological position (class) is 0.22, for trees of the second biological class it is 0.19 and for trees of the third biological class it is 0.19. The above indicates that the sequoia trees with their crowns overrun the space (mostly) in height (rather) than width.

6 REFERENCES

[1] Andonovski, A. (1978): Introduction of exotic species - important part of the substance of refinement of forest tree species, with emphasis on past experiences and opportunities in the Socialist Republic of Macedonia. Yearbook of the Faculty of Forestry. Paper 28, p. 59-67. Skopje

[2] Acevski, J., Nacevski, M., Vasilevski, K. (2000): Bioecological features and some physical and mechanical properties of trees of Sequoiadendron giganteum-Buch. Introduced in the Republic of Macedonia. Jubilee Yearbook of the Faculty of Forestry in Skopje, p. 181-186. Skopje.

[3] Velkovski N. Vasilevski K., Delov, K. (2012): Development of trees of *Seqoiadendron giganteum* (Lindl.) Buchholz), *Pseudotsuga mensiesii* (Mirb.) Franco) and *Pinus strobus* (L.) introduced in the area of the Gorun oak of Karadzica mountain. Anthology of Papers, Banja Luka, Republika Srpska, B & H.

[4] Velkovski, N. (2007): Bioecological feature and natural regeneration of beech forests of the Maleshevo Mountains (Doctoral dissertation), Cyril and Methodius University, Faculty of Forestry in Skopje.

[5] Ivanovski, C. (1978): Structure and productivity of pure beech plantations with rainforest character in the Osogovo Mountains (Doctoral dissertation), Cyril and Methodius University, Faculty of Forestry in Skopje.

[6] Крстевски, К., (1975): Студија карактеристика круне у ниским буковим пањачима (Магистерски труд), Шумарски факултет-Београд.

[7] Панић, Ѓ., (1966): Утицај биолошких положаја стабала и изграђеност њихових круна и продуктивност букових састојина на Руднику. Зборник Института за шумарство и дрвној индустрији СРС, кн. 26 Београд.

[8] Ristevski, P. (1984): Structural elements and productivity of beech plantations of mount Kozuv (Master's paper) UKIM Forestry Faculty in Skopje.

[9] Ristevski, P. (1984): Situation, productivity and impact of some elements of the crown on the productivity of black pine plantations in the area of the Maleshevo Mountains (Doctoral dissertation), Cyril and Methodius University, Faculty of Forestry in Skopje.

[10] Jurković, M., Jurković-Bevilacqua, B. (1996): Golemi mamutovac – *Sequoiadendron giganteum* (Lindl.) Buchh. u Zagrebačkim parkovima. Šumarski list бр. 1-2 CXX 47-53. Zagreb.

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

[11] Wolfgang, K. (1994): Giant Sequoia (*Sequoiadendron giganteum* /Lindl./ Buchholz) in Europe. USDA Forest Service Gen. Tech. Rep. PSW-151.