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CHARACTERISTICS OF NATURAL REGENERATION OF BEECH AND FIR IN OFFSPRING AND YOUNG FOREST DEVELOPMENT STAGES ON KORAB MOUNTAIN

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ABSTRACT: This paper presents research on the characteristics of natural regeneration of beech and fir in offspring and young forest development stages. Research is conducted in the natural forests of beech and fir represented on Korab Mountain. Data collection was performed through direct field research methods of test areas. The obtained data were processed through mathematical and statistical methods and are made appropriate analyses, of which the results are showed in tables and graphics. The paper includes data on natural conditions of the research area, and the situation with the parent plantation. Out of the carried research, the analysis was performed on the structure and development of the natural regeneration of beech and fir in offspring and young forest development stages. It was found that on the Korab Mountain the natural regeneration is in different stages of development but most of it is in offspring and young forest development stages. Most of the encountered individuals are aged between 5 and 20 years. Depending on the forest, stand density the participation of offspring in the total number of natural regenerations ranged from 59% with forest stand density of 0.5-0.6, 68% with forest stand density of 0.7 to 0.8 to 91% with forest stand density of 0.9 to 1.0, or about 85% of natural regeneration. The share of the individuals at young forest development phase ranges from 41% with forest stand density at 0.5-0.6, 32% with forest stand density of 0,7-0,8 to 9%with forest stand density between 0.9 to 1.0 or an average of 15%. At the same forest stand density and the same age, the individuals from natural regeneration of beech have some greater heights from individuals of natural regeneration of fir. Overall, natural conditions and the application of silvicultural and regenerative measures affect quality and structure of natural regeneration. The rise of forest stand density of 0.5 to 1.0 increases the number of individuals with poor quality, especially in fir. Of great importance for the survival and future sustainable development of beech and fir forests on the Korab Mountain is to grow quality and numerous natural regenerations of both tree species without compromising the quality structure of the parent trees and with no danger the ecological, economic, landscape and other features of these forests.
Keywords: beech, fir, development stages, Korab.

1 INTRODUCTION

Natural beech and fir forest stands represent significant forest richness for the Republic of Macedonia. Beech as a species is widespread in the Republic of Macedonia, but the contribution of the fir is insufficient and is mainly widespread in the western parts of Macedonia on the following mountains: Shar Planina, Korab, Bistra, Galicica, Baba, Nidze and Kozuv. The pure fir forest stands in Macedonia are represented at about 4.500 ha, and mixed forest stands with firs at 22.500 ha (Mircevski 1976). The beech in Macedonia is present on an area of about 270.000 ha, of which 220.000 are pure beech forest stands, and 50.000 are mixed beech forest stands (Dimitrov 1983). Mixed beech and fir forest stands are especially important because they are characterized by good structural characteristics and high production of wood. Some of the best quality beech forest stands in Macedonia are located in the National Park "Mavrovo". The spacious forest landscapes in this region together with its other natural values contributed to the establishment of the National Park-Mavrovo in 1949 with a legal explanation for "the particular natural beauties, the historical and scientific significance of the forests and forest landscapes around the Mavrovo field.

The Korab Mountain is located in the western parts of the National Park "Mavrovo". Korab is the highest peak in the Republic of Macedonia (Golem Korab), with a height of 2,764 m. The Korab represents a mountain-crowned arch with a stretch from south to north. Several plant and animal communities are flourishing here. The vegetation in this mountain consists of beech, beechwood, oak forests, as well as other plant formations. Some of them are managed, and part is not. In most of the plantations there is a natural regeneration of beech and fir. The regeneration is in different development phases, with different numbers and different quality and vitality. In some places, there is good progress in the regeneration process, while in some places there is stagnation or no natural regeneration at all. In places where there is a natural regeneration besides the other, there is also a decrease in the vitality of some individuals, their deformation, and the disappearance. Depending on the age of the individuals and the location conditions, there is a different success in the development of the beech and fir, indicating some future changes in the overall structure of the parent plantations.

Beech, fir and mixed beech-fir forest stands, as well as their structural and regeneration processes in Macedonia, were the subject of research by several researchers: Kosanin 1925; Dzhekov 1962; Em 1961, 1975; Nikolovski 1968; Mircevski 1976, 1977, 1978; Velkovski 2007, 2008; Andrijevski 2014 and others. The subject of research of this paper covers the beech and fir forest stands of Korab mountain. The research is focused in more detail on the development of natural regeneration of beech and fir in the development stages of offspring and young forest, which have a direct impact on the entire regeneration process of the stand. On the basis of the obtained scientific knowledge, the future silvicultural and regenerative measures in these forest stands can be optimally planned.

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2 METHOD AND RESEARCH OBJECT

Research was carried out on beech and fir forest stands on the Korab mountain. The area of research is located in the territory of the National Park "Mavrovo", in the northwestern part of the Republic of Macedonia. The research include the early development stages of the forest, ie. offspring and young forest. The research was carried out through direct field measurements using the methods of test surfaces. A total of 21 test surfaces with 4m² sizes have been placed. They are analyzed according to the classification and methodology of Shafar (1963). From the data on natural regeneration with mathematical calculation, mean values were obtained which were reduced and analyzed for a unit area of 1 ha. In addition, young individuals are classified according to their development stage, and an assessment of their quality has been carried out and on the basis of which their potential for quality and successful natural regeneration has been determined. The collected data from the performed measurements and research are processed with appropriate mathematical-statistical methods, and the obtained data are shown graphically and tabularly. The number of regenerations on area of 1 ha is calculated using the following formula:

N = (n x 10,000) / P

N – number of individuals at area of 1ha

n – number of individuals on the measured area

P – surface of the measured area

3 RESULTS AND DISCUSSION

The Korab Mountain, where research is being carried out for this work, mostly belongs to the submontane and montane continental-mountainous areas, where there is a stronger influence of the mountain climate and a small part in the subalpine continental-mountainous region, where a distinct mountain climate prevails. The relief is mountainous and features larger masses that gravitate towards the Dlaboka River and the Ribnichka River. The highest point on Korab Mountain is 1980 m and is located near the peak Mahija (2,002 m), and the lowest is at the place where Ribnichka River flows into Radika River and it has an altitude of 861m. The height difference between the highest and the lowest point is 1,119 m indicating a distinct mountain relief. The slope of the terrain of Korab Mountain is steep to very steepe, and in the northwest parts of the unit, in the ravines of Ribnichka River and Radika River is a cleef. In combination with altitude these sites are suitable for the success of mesophyll species and those species that are well supported by the cold regions.

On the Korab Mountain, several watercourses are formed, of which the larger ones are full-time and inexhaustible throughout the year, which is favorable for the successful development of mesophilic autochthonous tree species. The geologic base of the mountain consists mainly of filites, meta-tips and conglomerates, metamorphosed limestones and marbles, quartz, and on small surfaces there are massive limestones and diabase. On the Korab mountain there are three types of forest soils: acid brown soils, brown soils of limestone and brown rendzina. On acidic brown forest soils the beech forest stands are scattered, the brown soils of limestone are occupied by fir and beech-fir forest stands, while the brown rendzinas are occupied by European hop-hornbeam forest stands. According to the data from the meteorological station in Mavrovi Anovi on the Korab mountain, the mean annual air temperature ranges from 9.6□C at an altitude of 900 m to 4.6□C at an altitude of 1,900 m. The annual rainfall ranges from 966 mm at altitude from 900 m to 1,359 mm at an altitude of 1,700 m, and the mean annual relative humidity is 63%. The most frequent wind in this area is the northeast, with a frequency of 212%, followed by the southwestern, with 197%. The silence is represented by as many as 371%. The natural conditions of mountain Korab enabled the development of the beech and fir forest stands with the insignificant participation of maple and aspen, in this area, and in the lowest parts, on the expressly steep terrain, communities of European hop-hornbeam. The forest vegetation on the mountain Korab consists of beech, beech-fir, fir, oak forest stands and a small part of the scrubs and other forest stands. The occurrence of offspring in individual plantations of Korab mountain is mainly of beech and fir but with different quality and density, depending on the application of silvicultural and regenerative measures in the forest stands. The most common forest community on the Korab mountain is ass. *Abieti-Fagetum macedonicum*, with 49.7% of the covered forest area, followed by the ass. *Calamintho grandiflorae-Fagetum* with 34.7% of the surface. Other communities are less represented: ass. *Querco-ostryetum carpinifoliae macedonicum* at 10.1%, ass. *Orno-Quercetum petraeae* at 4.9% and ass. *Fago-Abietetum meridionale* with 0.6%. The natural conditions, that is, the conditions of the location of the tree species of beech and fir are identical, and therefore these species often occur as mixed beech and fir forest stands. The influence of natural conditions is complex and it is difficult to determine the impact of only one factor on the optimal development of a tree species due to their interaction, unless it is a limiting environmental factor, which has an impact in terms of reducing the ecological range of the species and on all other locality conditions.

Table I: Number of regeneration of beech and fir per area

		Forest stands canopy					
		0.5-0.6		0.7-0.8		0.9-1.0	
Number of regenerations on area of 1ha by development stages and by species		number of individuals	%	number of individuals	%	number of individuals	%
Offspring	beech	28715	62	22440	60	5119	45
	fir	17600	38	14960	40	6256	55
	Total	**46315**	**59**	**37400**	**68**	**11375**	**91**
Young forest	beech	29932	93	15312	87	855	76
	fir	2253	7	2288	13	270	24
	Total	**32185**	**41**	**17600**	**32**	**1125**	**9**
	Total	**78500**	**100**	**55000**	**100**	**12500**	**100**

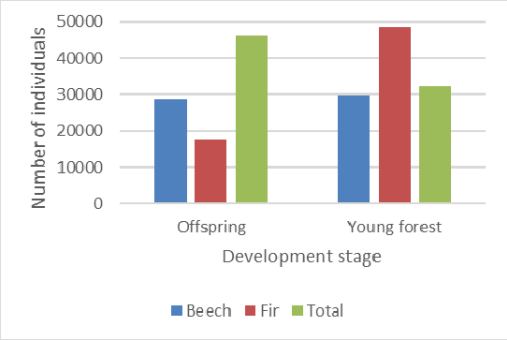

Figure 1: Number of regenerations by canopy of 0.5-0.6

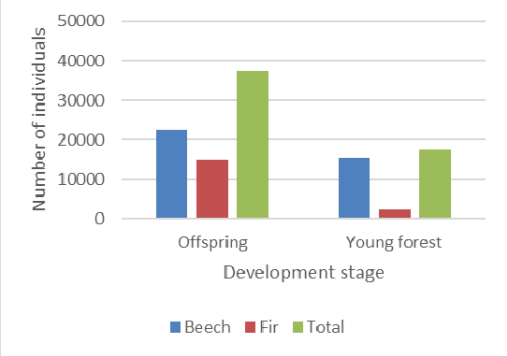

Figure 2: Number of regenerations by canopy of 0.7-0.8

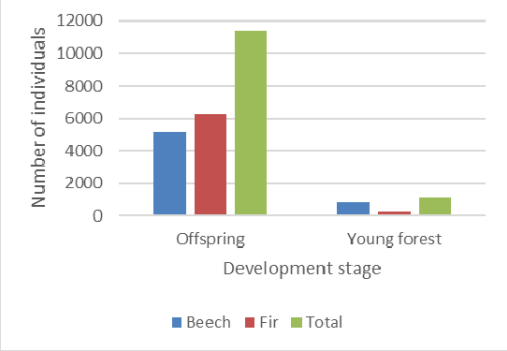

Figure 3: Number of regenerations by canopy of 0.9-1.0

Figure 4: Natural regeneration of fir and beech

The future development and composition of the plant depends largely on the structure of the natural regeneration in the stages of offspring and young sforest. The entire regeneration process of the forest stands directly depends on the number, age, height, diameter, quality structure and vitality of the individuals from natural regeneration.

The obtained results from the performed measurements and calculations are presented in Table I and Figures 1, 2 and 3, where the number of individuals is shown by type and development stage of the regeneration, and depending on the canopy of the forest stands.

From the presented data on the representation of natural regeneration of beech and fir in different development phases and with different canopy (0.5 to 1.0), presented in Table I and graphically presented in Figures 1, 2 and 3, it can be seen that the number of natural regeneration at different canopy of the forest stand is different. It is the largest in the most open as canopy of 0.5-0.6 (78500 individuals / ha), then it decreases so that in the 0.7-0.8 range it is (55000 individuals / ha), and at the 0.9 -1.0 is (12500 individuals / ha). This phenomenon occurs because with the increament of the forest stand canopy the access of light decreases, which is necessary for the development of natural regeneration. The age of the natural regeneration of beech and fir in the mixed beech-fir forest stands on Korab mountain was determined by analyzing the age of the individuals from the test surfaces determined by counting the annual rings at the base of the trunks. On this basis it has been established that individuals of different age range between 5 and 20 years of age. Individuals aged up to 10 years belong to the developmental stage of offspring, while those aged between 10 and 20 years belong to the developmental phase of the young forest. Depending on the canopy of the forest stand, the share of the offspring in the total number of natural regeneration ranges from 59% when the canopy of the forest stand is 0.5-0.6, 68% with forest stand canopy of 0.7 to 0.8% to 91% of the plantings of 0.9-1.0 or medium 85% of natural regeneration. The participation of the individuals from the development phase of the young forest ranges from 41% with an forest stand canopy of 0.5-0.6, then 32% with an forest stand canopy of 0.7-0.8 to 9% at the forest stand canopy of 0.9-1.0 or an average of 15%. From the above, it follows that, with greater shading, the participation of the individuals from the development phase of the young forest is significantly lower than in the enlightened areas. This clearly indicates that by increasing the age of the individuals and their transition from the development phase to offspring in the elderly development phase, they have higher light demands. Unless certain silvicultural measures are performed to increase the lightness of the young forest development phase individuals, they will largely die out due to lack of light.

The height of the natural regeneration of beech and fir in the mixed beech-fir forest stands at Korab mountain was determined through direct field measurements at the height of all the individuals from the test sites. In accordance with the classification of Shafar, individuals with a height of 1.30m are classified in the development phase of the offspring, while those with a height of 1.30m to 3.0cm chest breast diameter are classified in the development phase of the young forest. Of all the

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measurements performed, average values for the height of the natural regeneration of beech and fir according to the forest stand canopy were calculated. The values obtained are shown in Table II and Figures 4, 5 and 6.

Table II: Height of beech and fir natural regeneration

Mean height of natural regeneration by developmental phases and by species		Forest stands canopy 0.5-0.6 mean heght (cm)	0.7-0.8 mean heght (cm)	0,9-1.0 mean heght (cm)
Offspring	beech	120	102	79
	fir	111	84	65
Young forest	beech	308	257	224
	fir	245	188	150

From the presented data on the height of the natural regeneration of beech and fir in different stages of development and with different forest stand canopy (0,5 to 1.0), presented in Table II and graphically presented in Figures 4, 5 and 6, it can be seen that the height of the natural regeneration at different stages of development of forest stand is different. It is the highest in the most open canopy with 0.5-0.6 and then in the more closed canopy with 0.7-0.8 and 0.9-1.0 decreases. With equal forest stand canopy and the same age, the individuals of the natural regeneration of beech have slightly higher heights than the individuals of the natural regeneration of fir.

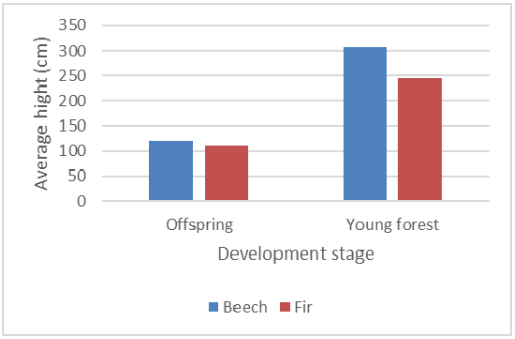

Figure 4: Hight of natural regeneration at canopy 0.5-0.6

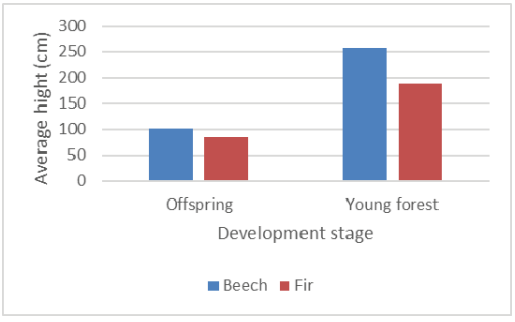

Figure 5: Hight of natural regeneration at canopy 0.7-0.8

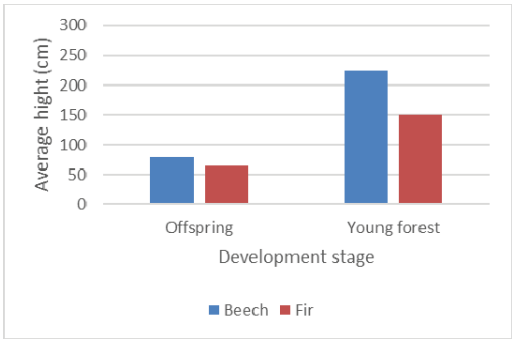

Figure 6: Hight of natural regeneration at canopy 0.9-1.0

The thickness of the natural regeneration of beech and fir in the mixed beech-fir forest stands at Korab mountain was determined by direct measurements of the thickness of the base of all the individuals from the test surfaces. Thus, in accordance with the belonging of the developmental stage, offspring or young forest, and depending on the forest stand canopy, the mean thickness at the base of the individuals of the natural regeneration is calculated.

The values obtained are shown in Table III and graphically shown in Figures 7, 8 and 9.

Table III: Thickness at the base of the individuals of the natural regeneration

Mean thikness of nat. regeneration by development stages and species		Forest stands canopy 0.5-0.6 mean thikness (cm)	0.7-0.8 mean thikness (cm)	0.9-1.0 mean thikness (cm)
Offspring	beech	2,1	1,2	0,9
	fir	2,3	1,5	1,0
Young forest	beech	3,8	3,6	3,4
	fir	4,1	3,7	3,2

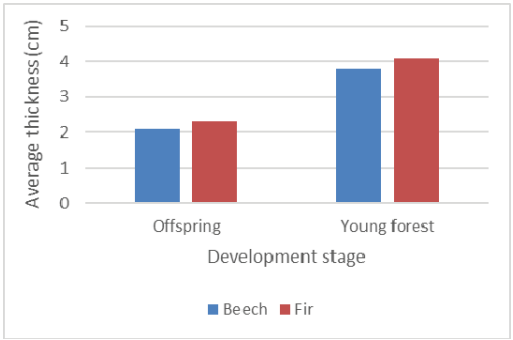

Figure 7: Thickness at the base of the individuals of the natural regeneration at canopy 0.5-0.6

Table IV: Quality structure of beech and fir natural regeneration at different forest stand canopy of mixed beech-fir forest stands

Quality structure of natural regeneration by developmental stages and by species		Forest stand canopy								
		0.5-0.6			0.7-0.8			0.9-1.0		
		good	medium	poor	good	medium	poor	good	medium	poor
Offspring	beech	71	14	15	65	19	16	52	22	26
	fir	65	18	17	59	22	19	55	24	21
Young forest	beech	55	25	20	52	25	23	41	24	35
	fir	50	21	29	25	26	49	9	33	58

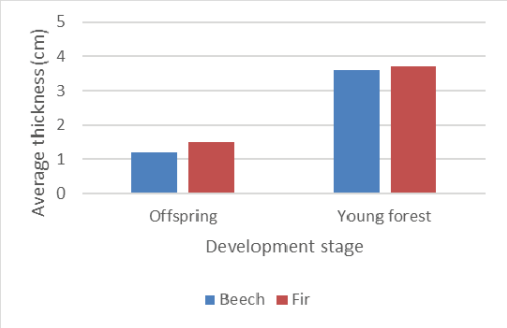

Figure 8: Thickness at the base of the individuals of the natural regeneration at canopy 0.7-0.8

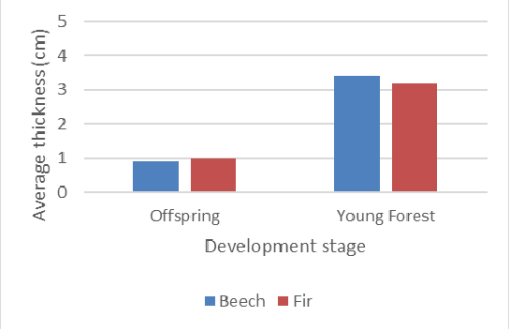

Figure 9: Thickness at the base of the individuals of the natural regeneration at canopy 0.9-1.0

From the presented data on the thickness at the base of the individuals from the natural regeneration of beech and fir in different developmental stages and with different forest stand canopy (0,5 to 1.0), presented in Table III and graphically prersented in Figures 7, 8 and 9, it can be seen that the thickness at the base of the individuals of the natural regeneration at different forest stand canopy is different. It is the highest among the offspring and young forest at the most open canopies 0.5-0.6, and then in the more closed canopies is 0.7-0.8 and 0.9-1.0 it continuously decreasing.

The quality structure of the natural regeneration in the mixed beech-fir forest stands at Korab mountain was determined by a comprehensive assessment of the quality of all the individuals from the test sites. In doing so, a standard gradation of the quality of the individuals of three quality groups was carried out, and it was performed on individuals with good, bad and medium quality.

In the first group as good quality individuals, all individuals with good health, good appearance and good vitality are grouped, ie. those in which the best genotypic and phenotypic potential is concentrated and which should be carriers of the future development of the forest stands.

In the second group as medium-sized individuals, all individuals with good health, good appearance and good vitality are grouped, but they lag behind the height and thickness growth behind the first group individuals. They are of much better quality than low-quality individuals and have a positive role in the forest stands because they maintain the initial density of natural regeneration and protect the soil from hardening and drying.

In the third group as poor quality individuals, all individuals with poor health, bad appearance and poor vitality are grouped. They are of poor genotypic and phenotypic characteristics and lag in the development behind other individuals of good and medium quality. A large number of them are with asymmetric crowns, dry tops, curved trunks etc.

The quality structure of the natural regeneration in the mixed beech-fir forest stands at Korab Mountain, depending on the developmental stage and the forest stand canopy, is presented in Table IV and graphically presented on Figures 10-15.

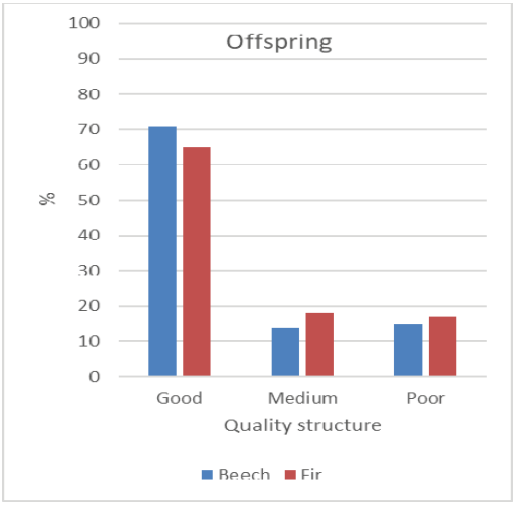

Figure 10: Quality structure of the fir natural regeneration (offspring) at canopy 0.5-0.6

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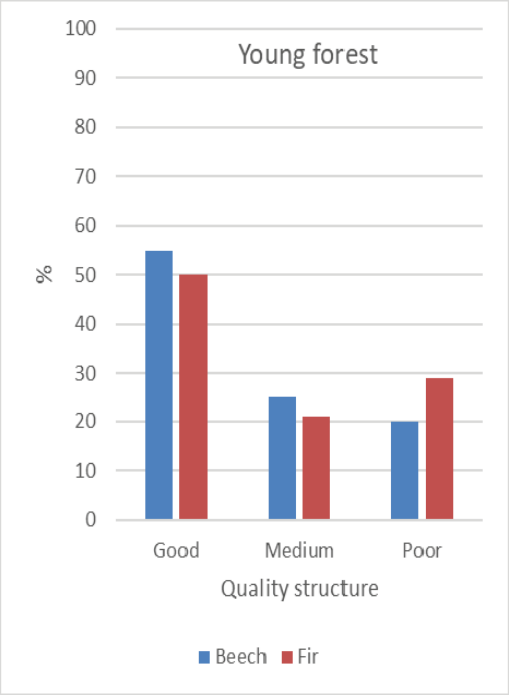

Figure 11: Quality structure of the fir natural regeneration (young forest) at canopy 0.5-0.6

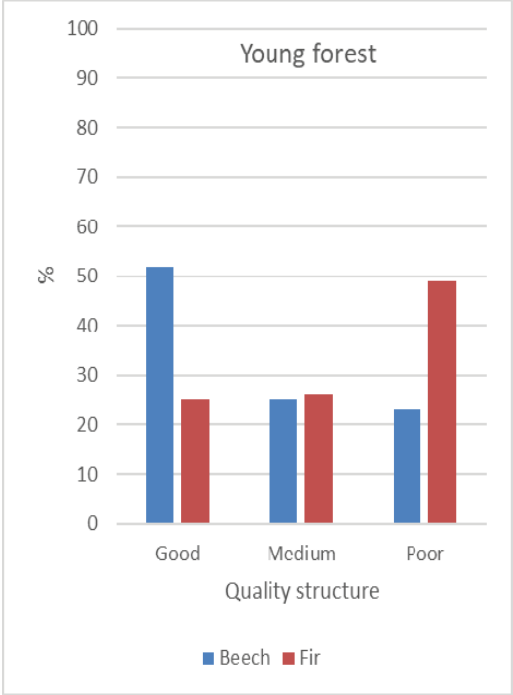

Figure 13: Quality structure of the fir natural regeneration (young forest) at canopy 0.7-0.8

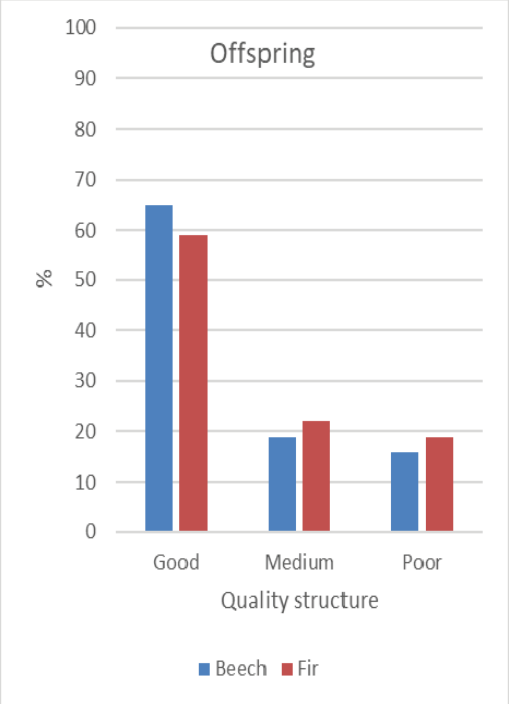

Figure 12: Quality structure of the fir natural regeneration (offspring) at canopy 0.7-0.8

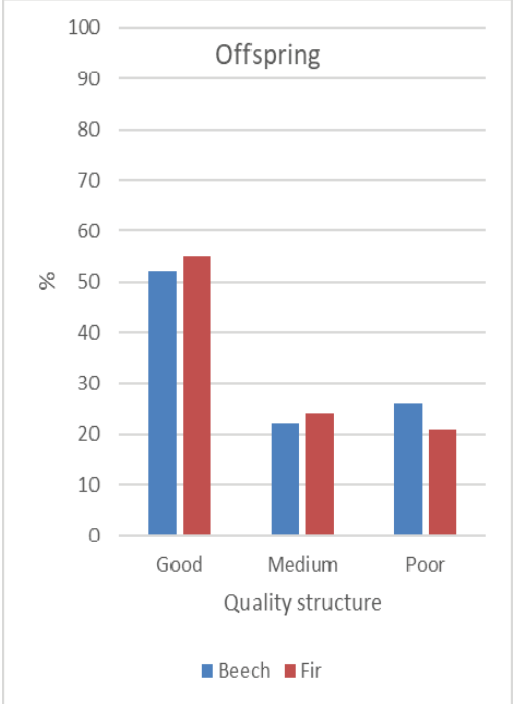

Figure 14: Quality structure of the fir natural regeneration (offspring) at canopy 0.9-1.0

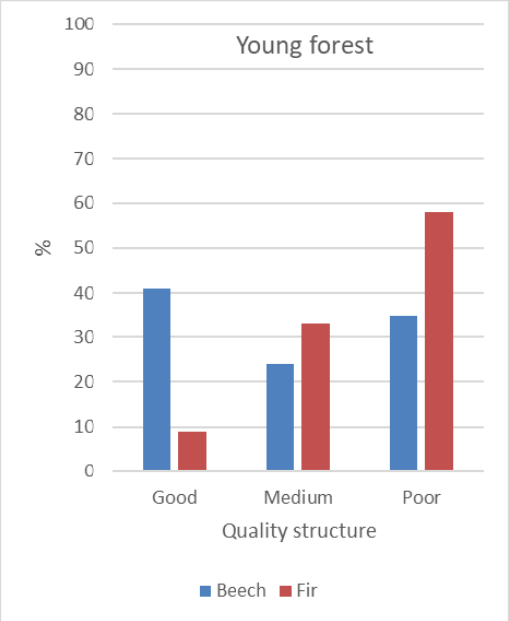

Figure 15: Quality structure of the fir natural regeneration (young forest) at canopy 0.9-1.0

From the data presented in Table IV and Figures 10-15, it can be seen that the highest percentage of beech and fir individuals of good quality at the offspring and the young forest is within the forest stand canopy of 0.5-0.6. With an increase of the canopy to 1.0, the percentage of individuals with good quality decreases. With the increase of the forest stand canopy from 0.5 to 1.0, the number of poor quality individuals, especially at the fir, is also increasing.

The overall natural conditions, as well as the application of silvicultural and regeneration measures in the forest stands, influenced the quality structure of the natural regeneration. With an increase of the forest stand canopy to 1.0, the percentage be of individuals with good quality decreases. This happens in individuals of both beech and fir, with the number of low-quality individuals being larger in fir trees. This suggests that the fir, although it is a shadow tolerant species, it requires greater enlightenment so that it can develop a larger percentage of individuals of good quality. Particularly unfavorable forests stand canopies for the fir tree individuals are 0.9 and 1.0 canopy. The poor quality of the fir individuals in these forest stand canopies is reflected in the fact that due to the unfavorable amount of light, it loses the growth in height which causes the extinction of top-terminal buds and the drying of the top most shoots. As a consequence, the fir trees form a widely branched side canopy, in order to compensate for the lack of upper light by laterally developing the branches. Because of this, individuals with poor quality with “umbrella” like crowns are formed (Fig. 16). If such individuals do not enlighten in time, they will perish.

Taking into account the overall natural conditions, the bioecological characteristics of beech and fir, as well as the traditional practices of mixed beech forest management in order to preserve and improve the quality structure of natural regeneration, it is necessary to carry out silvicultural measures in the early developmental stages. In the development stage offspring the thinings should be used for cleansing of the offspring, and in the development phase of the young forest, the thinings should be performed for lighting the offspring. In the later development of the young forest stand, thinings of moderate intensity should be performed, and in the period of forest stand maturation, the cuttings for space, should be performed.

Figure 16: Development of “umbrella” crown at young fir individual on Korab due to the lack of light

In mature mixed beech-tree forest stand, regeneration cuttings with intensity that correspond to the biological characteristics of both species should be performed. They will best regenerate by applying either of the combined methods of natural regeneration or by using a selective cutting. These cuttings correspond to mesophilic and shadow-tolerant species such as beech and fir and allow regulation of their composition and continuous improvement of their quality structure throughout their entire development. Thus, in these forest stands, quality and numerous natural regenerations can be cultivated, which will contribute to the permanent sustainable development of the beech forests of the Korab mountain, without disturbing the quality structure of the main forest stand and without jeopardizing the ecological, landscape and other functions of these forests.

4 CONCLUSIONS

The Korab mountain is characterised by imposing natural features, which are distinguished by high-altitudinal difference, expressed orographic characteristics and favorable hydrographic-hydrological regime. The natural characteristics of the terrain, climate and other factors contributed to the prevailing mesophilicsite conditions within the entire territory of t KorabMountain. Such natural features favorably influence the development of a large number of mesophilic species, dominated by beech, fir and beech-fir forests. The occurrence of offspring in the individual forest stands of Korab mountain is mainly of beech and fir but of different quality and density. In the first year of its development, in the developmental stage offspring the individuals of beech and fir has slow growth and reaches only about 10cm. In the further development, there is a somewhat more intense growth, which depends largely on the forest stand canopy and the flow of direct and diffused sunlight. The increament of the forest stand canopy has a direct impact on the reduction in the number, height, thickness and quality structure of the natural regeneration individuals. It is therefore necessary to timely carry out silvicultural and regeneration measures, as well as appropriate regulation of the forest

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stand canopy in order to enable a more optimal development of the natural regeneration. With equal forest stand canopy and the same age, the individuals of the natural regeneration of beech have slightly higher heights than the individuals from the natural regeneration of fir, which in the dense forest stand canopies forms also the so-called "umbrella" canopy with greater growth on the side than the terminal top shoots. Unless timely enlightenment of the natural regeneration is made, due to its weaker regeneration potential in dense and mixed forest stands of beech, conditions will be created for reducing the participation of firs in the composition of these mixed forest stands and in the long term transforming them into pure beech plantations.

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