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"Sustainable Forestry: Fact or Fiction?"
70 years
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PREFACE

Dear Colleagues and Readers,

It is a great pleasure to announce the online publication of the second issue of volume 48 of our journal Forest Review!

As we have already mentioned in the first issue of the Journal, UKiM Faculty of Forestry in Skopje celebrated 70 years of its establishment.

Therefore, we continue with the articles of the International Scientific Conference titled "Sustainable Forestry: Fact or fiction". Enjoy reading the articles from the respected authors who published their original work and new findings related to the topics of the Conference in our Review!

Great thanks to all authors and members of Forest Review, all peer – reviewers for their reviews of manuscripts for this jubilee volume and issues, all the participants and guests of the Conference, as well as to all those who have been involved not only with the Faculty of Forestry in Skopje, but also with the forest sciences in general.

On behalf of the Editorial Board,

Asst. Prof. Dr.sc. Bojan Simovski, Editor-in-Chief

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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**

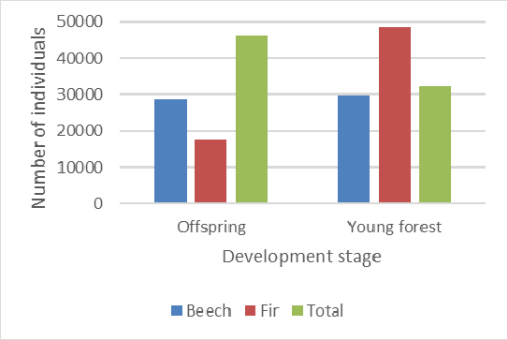

Figure 1: Number of regenerations by canopy of 0.5-0.6

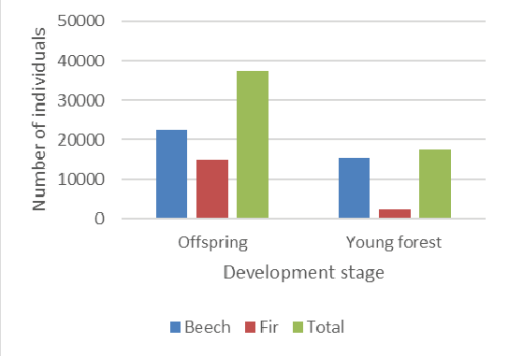

Figure 2: Number of regenerations by canopy of 0.7-0.8

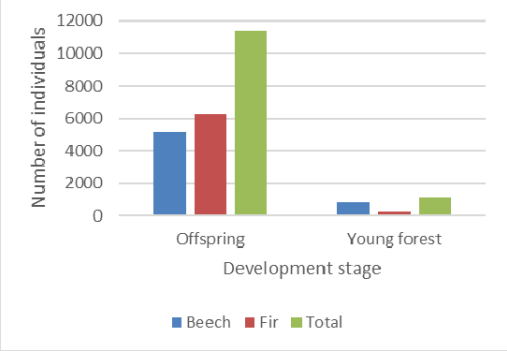

Figure 3: Number of regenerations by canopy of 0.9-1.0

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.

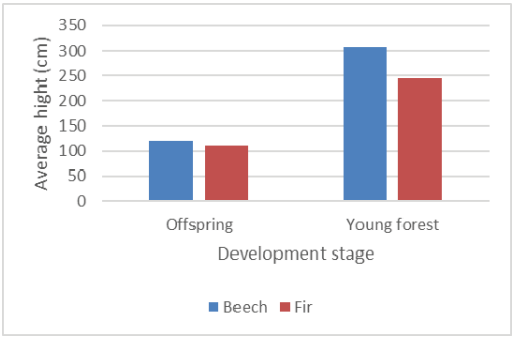

Figure 4: Hight of natural regeneration at canopy 0.5-0.6

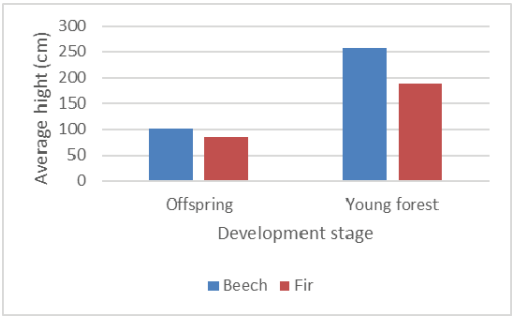

Figure 5: Hight of natural regeneration at canopy 0.7-0.8

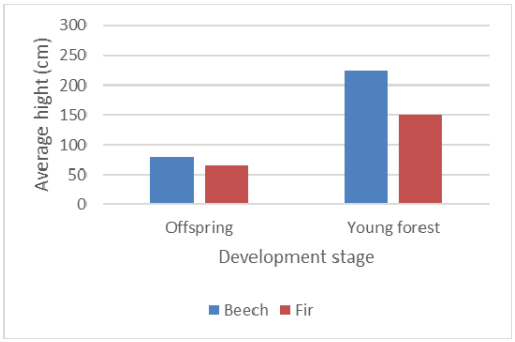

Figure 6: Hight of natural regeneration at canopy 0.9-1.0

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

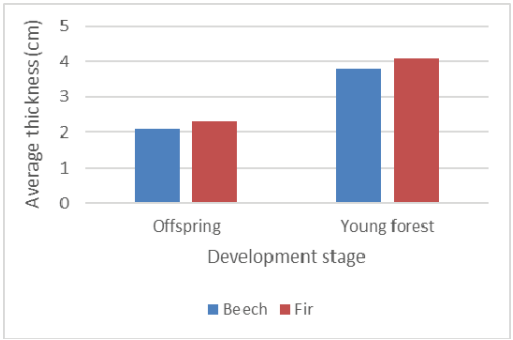

Figure 7: Thickness at the base of the individuals of the natural regeneration at canopy 0.5-0.6

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

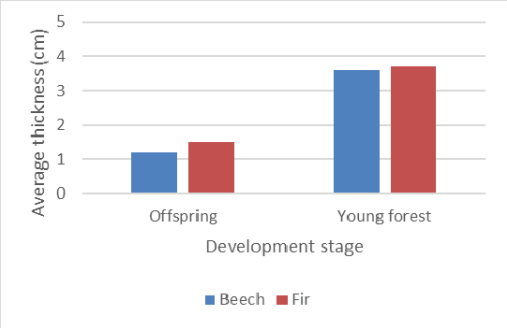

Figure 8: Thickness at the base of the individuals of the natural regeneration at canopy 0.7-0.8

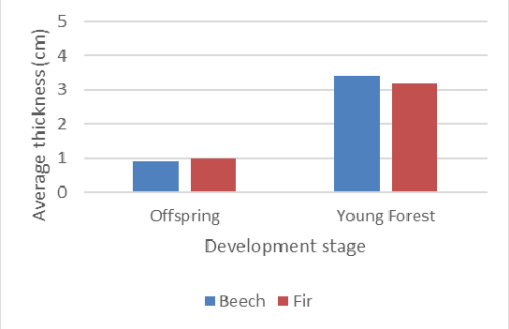

Figure 9: Thickness at the base of the individuals of the natural regeneration at canopy 0.9-1.0

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.

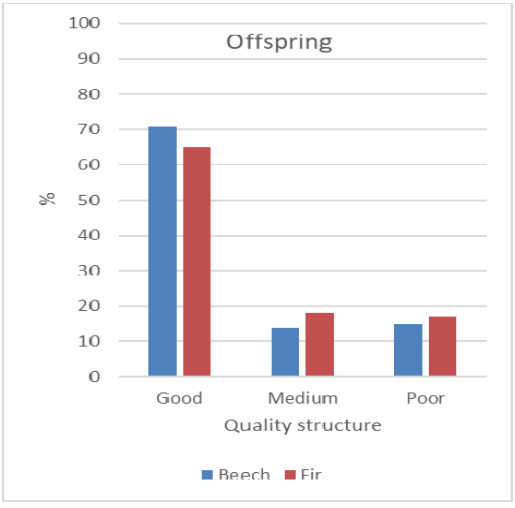

Figure 10: Quality structure of the fir natural regeneration (offspring) at canopy 0.5-0.6

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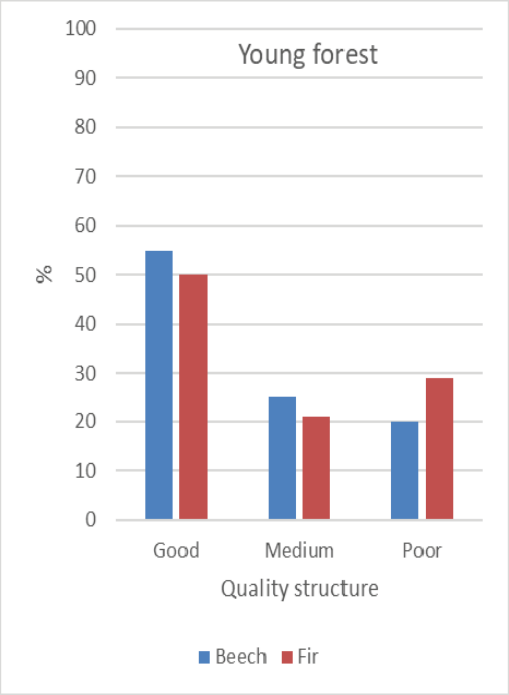

Figure 11: Quality structure of the fir natural regeneration (young forest) at canopy 0.5-0.6

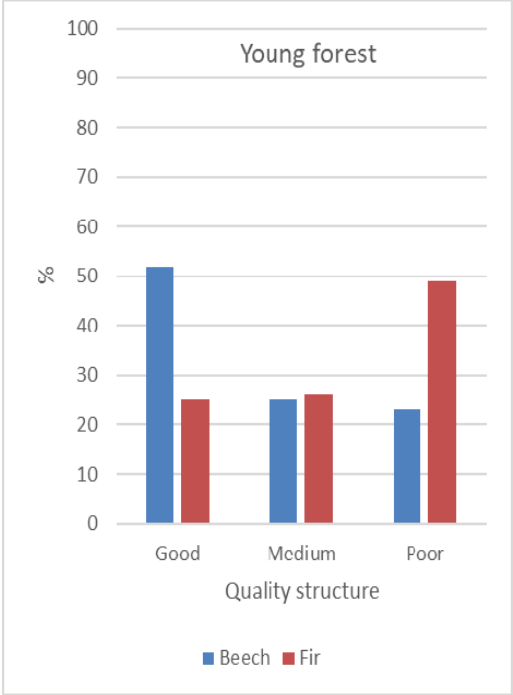

Figure 13: Quality structure of the fir natural regeneration (young forest) at canopy 0.7-0.8

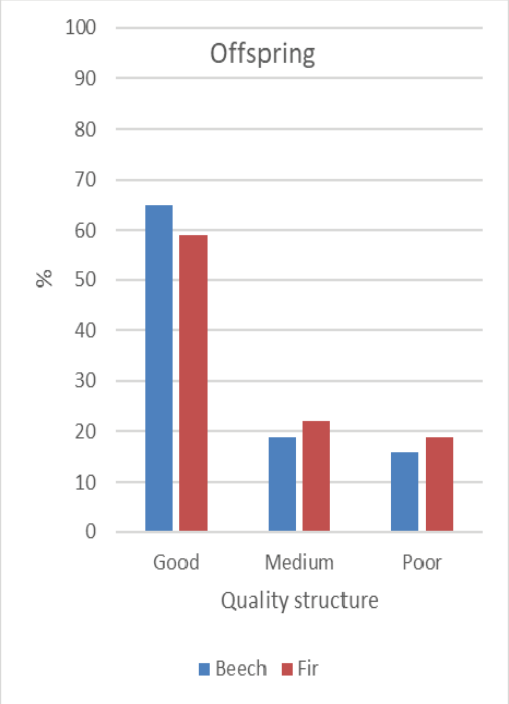

Figure 12: Quality structure of the fir natural regeneration (offspring) at canopy 0.7-0.8

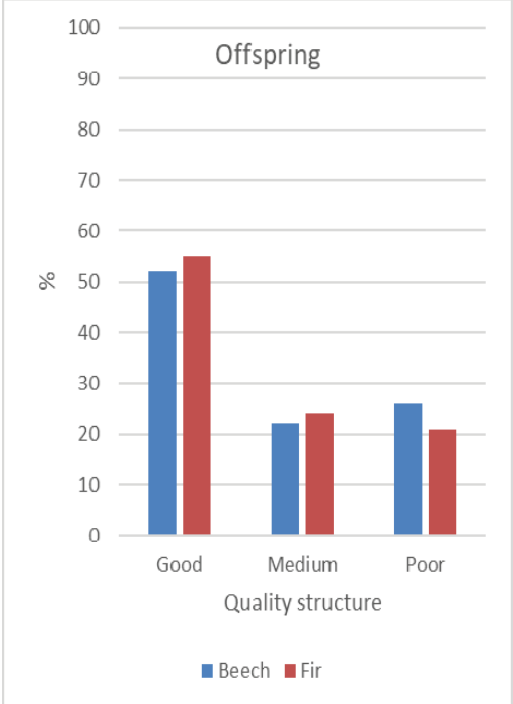

Figure 14: Quality structure of the fir natural regeneration (offspring) at canopy 0.9-1.0

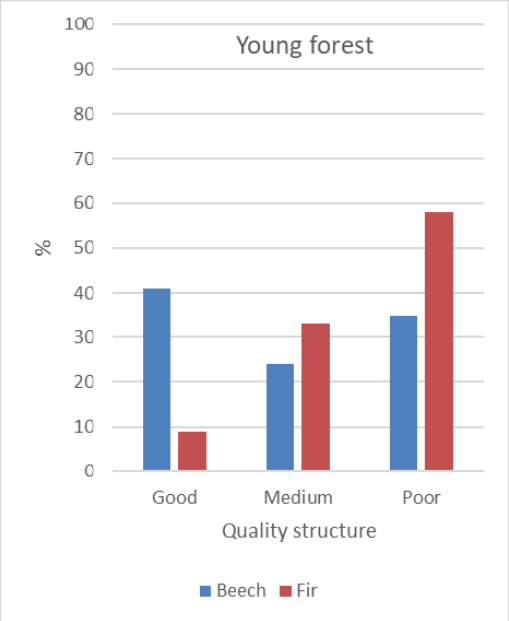

Figure 15: Quality structure of the fir natural regeneration (young forest) at canopy 0.9-1.0

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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Original scientific article

ECOLOGICAL CONDITIONS AND SUCCESSIONAL PROCESSES OF THE ABANDONED MOUNTAIN PASTURES IN THE REGION OF MALESH

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ABSTRACT: This paper presents the results of the research of the natural characteristics of the mountain pastures in the region of Malesh and the processes of their overgrowth with forest vegetation. The researches include mountain pastures in the region of Malesh, which are distributed between 1200 and 1932 m above sea level. These mountain pastures until the 1990s were more intensively used for grazing of small and large livestock (sheep and cattle), but after this period there is a noticeable decrease in the livestock, especially sheep, which lead to overgrowing of large areas of these pastures with different shrubs and forest vegetation. The purpose of this paper is to determine the natural succession processes that occur as a result of the afforestation of mountain pastures and the process of their overrun and transformation into young forest plantations. From the results obtained in the research, it was determined that the natural conditions in the Malesh region are favorable for persistence of large areas of mountain pastures on which a substantial number of large and small livestock can be grown. However, the natural conditions in the particular region are also favorable for the development of forest vegetation, due to which a large number of pioneer species are significantly distributed in the pastures on which no livestock is fed. The strong regeneration ability of these species contributes to intensive afforestation of the mountain pastures, whereto a significant part of them lose their function and gradually transform into young forests. This process is assisted by the reduction of livestock in the region and the land use reduction of these areas. Thus, for a period of only 30 years in some parts of these pastures occur intensive overrun processes resulting with a complete transformation of these parts of mountain pastures into young forest plantations
Keywords: site conditions, pasture management, succession.

1 INTRODUCTION

The region of Malesh is situated in the easternmost part of the Republic of Macedonia, bordering the Republic of Bulgaria (Fig. 1). It is characterized by high-developed relief with lowest point at only 660 m a.s.l and highest point at 1932 m a.s.l (Kadiica peak).

The region of Malesh is characterized by very rich hydrographic pattern. There are two bigger catchment areas: Bregalnica and Strumica rivers, which further flow in the Aegean watershed. The catchment area of the river Bregalnica covers mainly the higher mountainous region. The slope of the watershed is steep, where the right side is more developed, i.e. has more tributaries, such as: Ravna River, Ratevska River, Klepalska River, Zamenichka River, Rusinska River, Kamenichka River, Lenishka River and Zhelevica.

Figure 1: Location of Malesh region

Natural conditions have a major impact on vegetation development at a certain area. Depending on the natural conditions at the studied area various plant species (wooded and herbaceous) are represented and exist. The existing natural conditions represent optimal values for development of some plant species, but also are limiting factor for development of others. Present plant species have found optimal conditions for their development at the researched area. On the other hand, the altitude is the most limiting factor. The treeline extends up to 1746 m a.s.l. At higher altitudes are developing pasture communities. Plant communities in the high mountains in Macedonia are investigated by Horvat, I. (1933) and Rudski, I. (1938). The forest vegetation in Malesh and Pijanec is explored by Dzekov, S. and Rizovski, R. (1978). At the researched area are present the following forest communities ass. *Quercetum frainetto-cerris*, ass. *Quercetum frainetto-cerris* subass. *pinetosum nigrae*, ass. *Orno-Quercetum petraeae*, ass. *Orno-Quercetum petraeae* subass. *pinetosum nigrae*, ass. *Fago-Pinetum nigrae*, ass. *Festuco heterophyllae-Fagetum*, ass. *Calamintho grandiflorae-Fagetum* and shrublands of common juniper (*Juniperus communis*) [2].

The vegetation of meadows and pastures in Malesh and Pijanec is explored by Micevski, K. (1978.) The pastoral communities at the investigated area belong to the alliances Armerio-Potentillion (ass. *Genisto-Agrostideum byzanthinae*) and Poion violaceae (ass. *Thymo-Poetum violaceae* and *Thymo-poetum violaceae* subass. *chamaespartietosum*) [7]. The possibilities for improving the conditions of pastures, forests, forest land and primary wood processing in Malesh and Pijanec are studied by Rabadziski, B. and Vasilevski, K. (2001).

The management of forest resources in the region of Malesh has a long tradition but mainly done in a traditional manner [1]. Ecological conditions (relief, altitude, inclination, exposure, hydrology, geology, soil and climate features) have major importance for the vegetation on mountain pastures due to their impact on microclimate and mesoclimate conditions at all areas [4].

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This region was once known for animal husbandry and majorly sheep farming prevalence due to numerous mountain pastures, favorable natural conditions and good opportunities for animal breeding, activities which had a major role in maintaining mountain pastures. Mountain pastures are zoogenic and anthropogenic areas where changes in vegetation occur constantly [13]. The number of livestock and application of extensive management practices at mountain pastures had an impact on their appearance. Nowadays in the mountainous area of the Malesh region are visible processes of afforestation that lead towards overgrowth of mountain pastures with forest vegetation. Natural regeneration of some indigenous forest tree species at sites without forests in the Malesh region is explored by Velkovski, N. et al. (2008). The vegetation of pastures in Maleshevo is examined by Teofilovski A. (2011).

The period of 1990s caused a massive depopulation of the region leading to drastic reduction of livestock and afforestation of the areas previously pressured intensively by the population and livestock. This phenomenon leads to reduced quality and quantity of the mountain pastures, influenced by the successive processes and allow transformation of the pastures into young forest plantations.

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2 METHOD AND RESEARCH OBJECT

The subject of this study are the successional processes of mountain pastures in the region of Malesh distributed between 1200 and 1932 m above sea level and its relation with the ecological conditions at the area. The aim is to determine the influence of the abandonment of pasture management on successional processes in the region of Malesh. Therefore, main task of the research is collecting field data and their analysis to determine successional processes of the vegetation.

In achieving these aims and tasks have been realized numerous activities such as: exploration of anthropogenic and zoogenic influence and its significance regarding the processes of ecological succession, selection of representative areas, setting of 12 experimental plots of 500 m^2 (25 x 20 m) and demarcation of their borders. The areas for setting experimental plots were chosen according to following criteria: 1. Areas have similar environmental characteristics, 2. Areas have similar floristic composition and 3. Areas are abandoned i.e. no visible signs of anthropologic and zoologic influence.

Each experimental plot is set by firstly positioning the starting point (the south west point), then setting the west border by pointing a compass and prism measuring instrument to north and measuring of the 20 m length to determine the north west point, followed by same approach from both points with 90º turn and measuring 25 m to east to determine the north east and south east points and final control distance measurement between the last two points of 20 m. The starting point and the boundaries of each plot are recorded with a GPS device and referenced in WGS84 coordinate format. Thereby, at all sample plots are determined: altitude, exposure, slope of terrain, soil type, and plot inventory to determine the presence of different forest species and other (accompanying) plant species and number of individuals per sample plot including measuring of their dimensions (height of stem, diameter of crown, diameter at breast height). At precisely defined sub-plots of 50 m^2 (2 x 25 m), placed in the middle of the 12 main experimental plots stretching from west to east, is undertaken detailed inventory and measurements of the position and dimensions of the individuals to analyze the succession dynamics. Data from field measurements are recorded in forms, and then mathematically processed. The spatial distribution of the experimental plots is given on the map below (Fig. 2).

The climate characteristics of the area were determined based on obtained data from climate station in Berovo, located at an altitude of 824 m, including: average monthly minimal and maximal air temperatures, monthly sum of precipitation, sum of precipitation over the growing period, annual sums of precipitation and speed and frequencies of the winds.

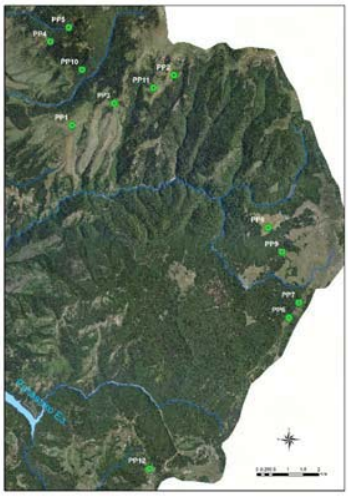

Figure 2: Experimental plots spatial distribution

3 RESULTS AND DISCUSSION

The overall status of the ecological conditions in the region of Malesh and the successional processes of the area is noticed through analysis of the provided data from the climate station in Berovo, comparison of the vegetation data from pervious researches and the collected field data and adoption of relationship between site conditions and successional processes.

The relief of the Region of Malesh is quite widespread, intersected with many ravines that rise above the lower and higher sides of the hills and mountains that extend generally from west to the east and northeast.

The altitude has important influence on existence and development of vegetation at the area. The lowest point in the region has an altitude of 660 m, while the highest point of 1932 m (Kadiica peak). The forest line extends up to 1746 m a.s.l. At higher altitudes are developing pasture communities. It is the most limiting factor. Increase of the altitude changes climate characteristics adequately.

Exposure or aspect generally refers to the horizontal direction to which a mountain slope face. It has an impact on other environmental factors, as well as the occurrence of various types of forest in a certain area. Various types of aspects are met at the studied area and presented in Table I.

The slope (inclination) of the terrain is tilted at an angle on which all other natural conditions in a given

environment largely depend. The rising slope of the terrain increases the risk of erosion, increases the intensity of leakage of surface and ground waters, so the amount of moisture in the soil decreases and the soil depth and layers are reduced. Natural conditions that are influenced by the slope are very important for determining the silviculture measures. Analysis of the available data indicate that the terrain of Malesh region has moderately steep slopes up to steep and very steep slopes, which combined with the higher altitude at the research area provide favorable natural preconditions for development of pastoral communities' at large areas. In Table I are shown the slopes of every experimental plot

Table I: Experimental plots aspect and slope

Experimental Plot	Aspect	Slope (%)
EP1	SW	10,4
EP2	SE	37,9
EP3	SW	20,9
EP4	W	25,4
EP5	W	46,7
EP6	N	12,0
EP7	NW	1,6
EP8	SW	9,0
EP9	W	11,3
EP10	SW	36,4
EP11	W	21,4
EP12	NW	15,5

Soil conditions in the region of Malesh are represented by five soil types including: Regosol, Chromic Luvisol on saprolite, Complex of Humic Eutric and Umbric Regosol, Cambisol and Lithic Leptosol. Pastoral succession currently occurs at Regosoles or Complex of Humic Eutric and Umbric Regosol (Fig. 3).

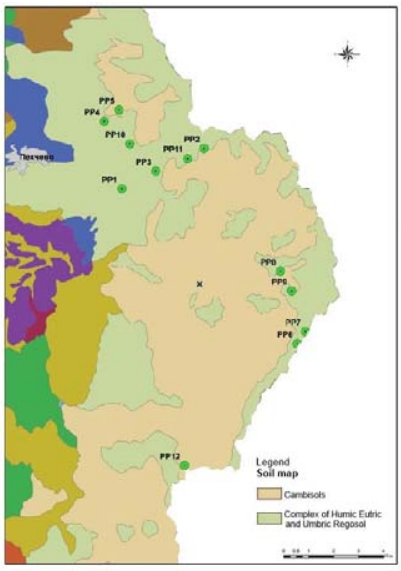

Figure 3: Soil types at the researched area

Climate data are obtained from meteorological station in Berovo, located at an altitude of 824 meters. The processed data for average monthly temperatures and monthly amounts of rainfalls for the period 2001 to 2010 are used for preparation of Walter's climate diagram for Malesh region (Fig. 4). The mean annual temperature for the period from 2001 to 2010 is 9,3°C, while the average amount of rainfall is 699,4 mm.

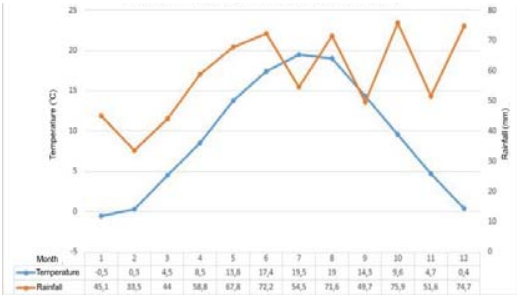

Fig. 4: Walter's climate diagram for Malesh region

Close relationship is revealed between successional processes of abandoned pastures in the region of Malesh and the relevance of anthropogenic and zoogenic factors at the region. Data on demography and mitigation processes provided by the State Statistical Office (SSO) indicate constant declining population trend line (Table II and Fig. 5).

Table II: Population in Malesh region

Year	Urban	Rural	Total
1948	5 306	13 711	19 017
1948 (%)	27,9	72,1	
1953	5 926	14 512	20 438
1953 (%)	29.0	71,0	
1961	6 116	13 932	20 048
1961 (%)	30,5	69,5	
1971	6 974	12 987	19 961
1971 (%)	34,9	65,1	
2013	9 442	10 016	19 458
2013 (%)	48,5	51,5	

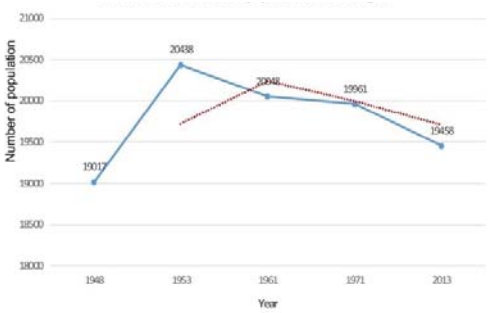

Figure 5: Trendline of population in Malesh region

This phenomenon is caused by the migration of the population from rural to urban areas as well as permanent emigration from the region. It also contributed in land use change. Data on land use indicate process of returning of the forest vegetation at areas formerly pressured by various human activities (Table III). Identified arising issue is human induced afforestation in the high mountain areas with various monocultures (e.g. pines) and providing solid ground for fast advancement of pioneering forest species (mainly coniferous).

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Table III: Land use in the region of Malesh

	Total agricultural land (ha)	Arable area (ha)	Pastures (ha)	Forests (ha)
1976	68 218	36 006	32 212	49 613
2011	75 019	32 950	42 068	63 863
Difference	6 801	-3 056	9 856	14 250

Table IV: Number of sheep and cattle in the region of Malesh

	Cattle 2014	Cattle 2007	Cattle 1976	Difference 1976-2014	Sheep 2014	Sheep 2007	Sheep 1976	Difference 1976-2014
Berovo	2 214	2 290	8 240	-4 019	21 771	26 226	47 601	-16 513
Pehcevo	2 007	1 839			9 317	10 647		

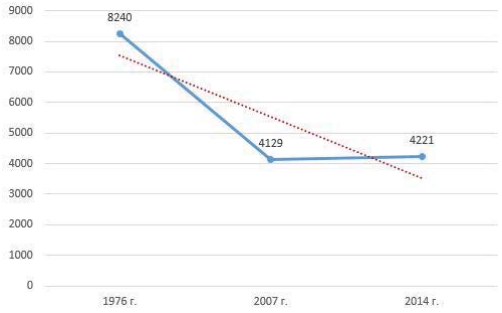

Figure 6: Trendline of cattle in Malesh region

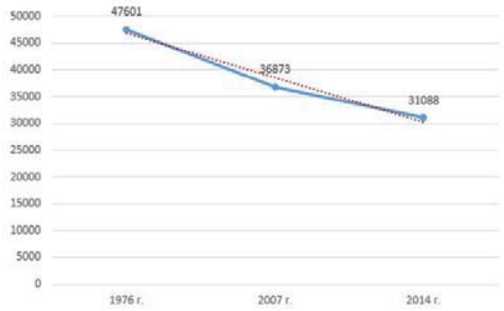

Figure 7: Trendline of sheep in Malesh region

Table V: Summary of the experimental plots data

Category	Experimental plot	Altitude (m)	Number of individuals	Number of taxa	Stage of Succession	Restoration measures
1 - 10 years	EP1	1297	82	5	Initial	Mowing, Firing
	EP8	1492	184	6	Initial	Mowing, Firing
	EP9	1517	253	3	Initial	Mowing, Firing
11 - 20 years	EP3	1426	130	6	Progressive	Mowing, Firing Removal
	EP6	1550	284	12	Progressive	Mowing, Firing Removal
	EP7	1557	208	8	Progressive	Mowing, Firing Removal
21- 30 years	EP2	1575	236	10	Intensive	Mowing, Firing Removal
	EP11	1533	55	5	Progressive	Mowing, Firing Removal
	EP12	1362	80	8	Intensive	Mowing, Firing Removal
Over 30 years	EP4	1408	223	7	Forest	Not applicable
	EP5	1483	100	7	Forest	Not applicable
	EP10	1387	88	8	Forest	Not applicable

Decreased population and livestock in the region lead to decreased livestock pressure over the mountain pastures, allowing space for easier emergence of certain plant species with strong regeneration capability and relatively quickly inhabit places such as abandoned mountain pastures. Such phenomenon contributed in acceleration of succession processes at different stages and emergence of forest vegetation on some pastures, strongly expressed in areas where mountain pastures have been abandoned for long periods.

Up to 10 years of abandonment of the pastures initially appear pioneering, heliophylous, ruderal and invasive mainly annual and perennial herbaceous plants, with appearance of individual shrubby species of the type of low bushes.

Later, between 11 and 20 years of abandonment, increases the number of individuals and taxa of woody shrubs, as well as their size and coverage. Sometimes in this period, and almost regularly during the period between 21 and 30 years of abandonment, occurs a stratification of the bushes.

After 30 years of abandonment at the area of the

former pasture begins to establish the stratum of the trees (with height over 5m), and in the stratum of the bushes are found species that can thrive in shade.

Main forest woody species that colonize the abandoned pastures are: *Juniperus communis*, *Pinus nigra* and *Pinus sylvestris*. Associated species are: *Chamaecytisus absinthioides, Rosa canina*, *Prunus cerasifera*, *Prunus spinosa*, *Crataegus monogyna*, *Coryllus avellana*, *Sorbus aucuparia*, *Mallus sylvestris*, *Rubus fruticosus*, *Rubus idaeus*, *Epilobium* spp., *Carlina acaulis*, *Onopordon acanthium*, *Eringium campestre*, *Verbascum* spp. and *Pteridium aquilinum*.

3 CONCLUSIONS

The rapid and intense successional processes of mountain pastures in the region of Malesh despite the reduction of livestock, the decrease of their utilization and their abandonment, are also influenced by the favorable site conditions for occurrence of forest vegetation as well as numerous pioneering species that have strong regeneration ability to inhabit the abandoned mountain pastures and other similar grounds.

Main factor for successional processes on pastures in the region of Malesh is the declining anthropogenic and zoogenic impact on the area by continuous reducing of the population and livestock in the region of Malesh. Data on land use indicate process of reoccurrence of the forest vegetation at areas formerly pressured by various human activities.

Ecological characteristics at the researched area, in absence of anthropogenic and zoogenic pressure, provide favorable conditions for advancement of numerous pioneering forest trees and shrubs. Data points out rapid and intensive afforestation of the pastures in the region of Malesh and their transformation into areas with forest vegetation due to the favorable ecological conditions. This is especially typical for areas up to 1550 m altitude. At higher altitudes successional intensity is lower due to severe micro climate conditions and emergence of numerous shrub species.

The vegetation change of the high mountain pastures and decrease of their area is negative phenomenon that endangers the fulfillment of their functions, but also reduces the diversity and values of the landscape.

Restoration measures for reclamation of the pastures abandoned up to 20 years are necessary! Otherwise, after about 30 years, forest vegetation will prevail at the areas with pastures. That might cause loss of significant part of overall biodiversity. Former pasture areas, abandoned over 30 years, can be considered as irreversibly afforested by typical forest vegetation. In such case, restoration measures for reclamation of such areas in their previous state are economically and biologically unreasonable.

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Original scientific article

SCABIOSA LUCIDA VILL. (DIPSACACEAE), A NEW SPECIES IN THE FLORA OF THE REPUBLIC OF MACEDONIA

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ABSTRACT: *Scabiosa lucida* is recorded for the first time for the flora of the Republic of Macedonia. Newly discovered population is located on Osogovo Mts, in north-eastern part of the Republic of Macedonia, nearby the border with Bulgaria. This finding confirms also the previous record for the Bulgarian side of the mountain. The species was recently recoded for another border mountain (ridge Kobilica on Šar Planina Mts), also at the other side of the border, this time in Kosovo. *S. lucida* is a mountainous element, distributed in central and southern Europe. The species belongs to the very complex group of *Scabiosa columbaria*. Certain features, like the hairiness of the leaves and the shape of the calyx-setae, in the fruit stage, make clear distinction between this and the other closely related species of the same group.
Keywords*: Scabiosa lucida*, Osogovo Mts., Republic of Macedonia.

1 INTRODUCTION

The research of the genus *Scabiosa*, in the flora of the Republic of Macedonia, is not finished yet. The approximate number of the species, according to the available literature data (Griesebach, 1843; Wettstein, 1892; Degen & Dörfler, 1897; Beck von Managetta, 1904; Adamović, 1905; Dimitrov, 1908; Košanin, 1909; Vandas, 1909; Velenovsky, 1922; Jurišić, 1923; Urumov, 1923; Bornmüller, 1925/26/28, 1927, 1937; Csiki, Javorka & Kümmerle, 1926; Stojanov, 1928; Soška , 1938, 1938/39b, 1939, 1941, 1953; Rechinger, 1939; Petrović, 1941; Černjavski, 1943; Rudski, 1943; Weber, 1951; Micevski, 1952, 1978, 1994; Todorovski, 1954, 1963, 1970; Cirimotić (=Matvejeva), 1958, 1965; Grupče, 1958; Em, 1962;, Šmarda, 1968; Drenkovski, 1968; Matevski, 1995; Teofilovski, 2011; Nikolov, 2017), following the system of Jasiewich (1976), is 18. Beside the already alleged *Scabiosa rhodopensis* Stoj. & Stef., as a Balkan endemic species, with very restricted distribution on the territory of the Republic of Macedonia (Nikolov, 2017), there is another one, from this genus, that also attracts attention. It is *Scabiosa lucida* Vill. which, according to the available literature data, appeared to be new for the flora of the Republic of Macedonia. It is a mountainous element distributed in central and southern Europe (Jasiewicz, 1976; Domina, 2017). On the Balkan Peninsula this species has not yet been recorded in Bosnia and Herzegovina and Greece. *S. lucida* grows on forest clearings, mountain meadows, pastures and rocky places, from montane to alpine zone, at the altitude of (1200) 1500–2700 m.a.s.l. (Grossman, 1975).

2 MATERIALS AND METHODS

Plant material, collected during the field surveys on Osogovo Mts (2002, 2012, 2013 and 2018), is stored in the herbarium of the Macedonian Museum of Natural History (HMMNH). Different literature sources were used for the identification of the material (Prodan, 1961; Diklić, 1973; Grossman, 1975; Jasiewicz, 1976; Petrova, 2012). Photos from the habitat, plant and its different parts were also made. Distribution map is presented, as well (Fig. 2).

Figure 1: *Scabiosa lucida* Vill. - a) species habitat b) flowering plant

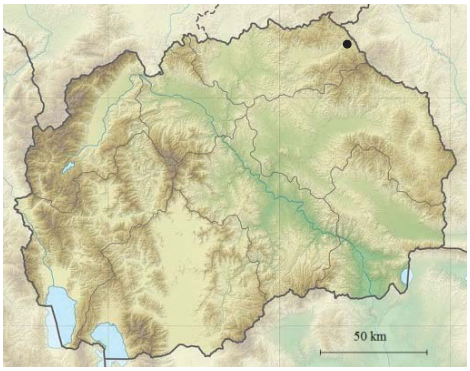

Figure 3: Distribution of *Scabiosa lucida* Vill. in the Republic of Macedonia

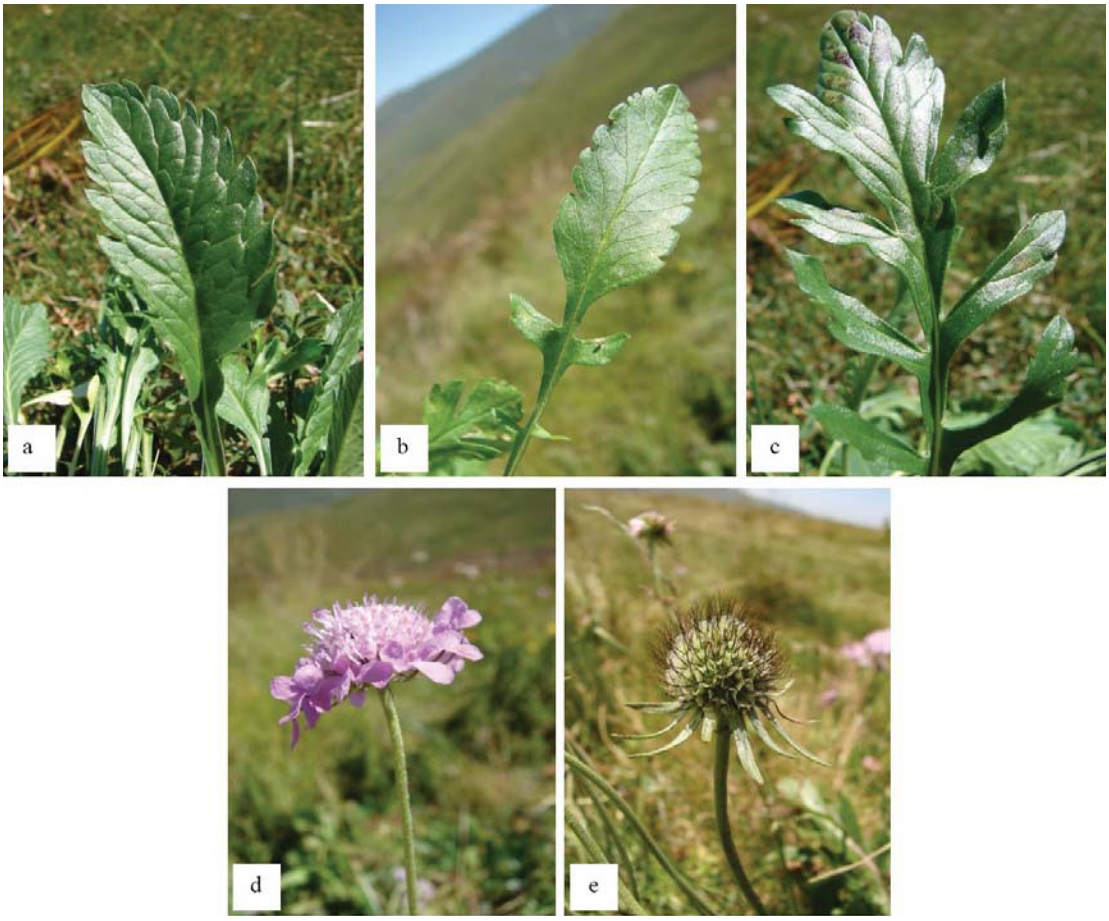

Figure 3: *Scabiosa lucida* Vill. – a,b,c) - basal leaves d) flower e) fruit stage

3 RESULTS AND DISCUSSION

Mk.: Osogovo Mts (Kriva Palanka): mountain pastures above the mine "Toranica", 1600-2200 m.a.s.l., 18.07.2013 (Leg./Det.: Z. Nikolov).

Very abundant population of this species was observed on the mountain pastures on Osogovo Mts, from above the mine "Toranica" to the very peak of Ruen, near the border with Bulgaria. So far, *S. lucida* is not recorded on the territory of the Republic of Macedonia. However, data about the presence of this species on Osogovo Mts, in general, already existed, for the Bulgarian side of this border mountain (Velenovsky, 1891). So, our new finding is, beyond the importance as a new species for the flora of the Republic of Macedonia, contribution to the distribution area of this species on the Osogovo Mts as well as on the Balkan Peninsula, in general. There is one more recently published record that also deserves attention. In the paper of Duraki, Stanojević & Stojanović (2017), the presence of *S. lucida*, for the Kosovo-side of the ridge Kobilica (Šar Planina Mts) was alleged. However, during our field surveys (2007, 2018) the presence of this species was not confirmed on the Macedonian side of the ridge Kobilica.

Scabiosa lucida belongs to the group of *S. columbaria* (Jasiewicz, 1976) that, contrary to *S. ochroleuca* group with yellow or whitish corolla, includes taxa with purple or reddish corolla (Fig. 2, d). Within the group of *S. columbaria*, *S. lucida* has stable taxonomic rank through certain characteristics that make clear distinction from the other closely related taxa. For example, from the closest *S. columbaria* L., *S. lucida* differs in the hairiness of the leaves and the shape of the calyx-setae (Grossman, 1975; Jasiewicz, 1976). Namely, the leaves of the *S. lucida* are glabrous or subglabrous and the calyx-setae are distinctly widened at base, in the fruit stage, while the leaves of the *S. columbaria* are usually hispid and the calyx-setae are not widened at base, in the fruit stage.

The plants from the Osogovo Mts match the description given by Diklić (1973), Grossman (1975), Jasiewicz (1976), Petrova (2012). Leaves are more or less glabrous with rare hairs on the margins, on the midrib of the both surfaces of the leaves as well as on some veins on the lower surface (Fig. 4, a-f).

The calyx-setae, contrary to *S. columbaria* (Fig. 5, a), are widened at the base (Fig. 5, b).

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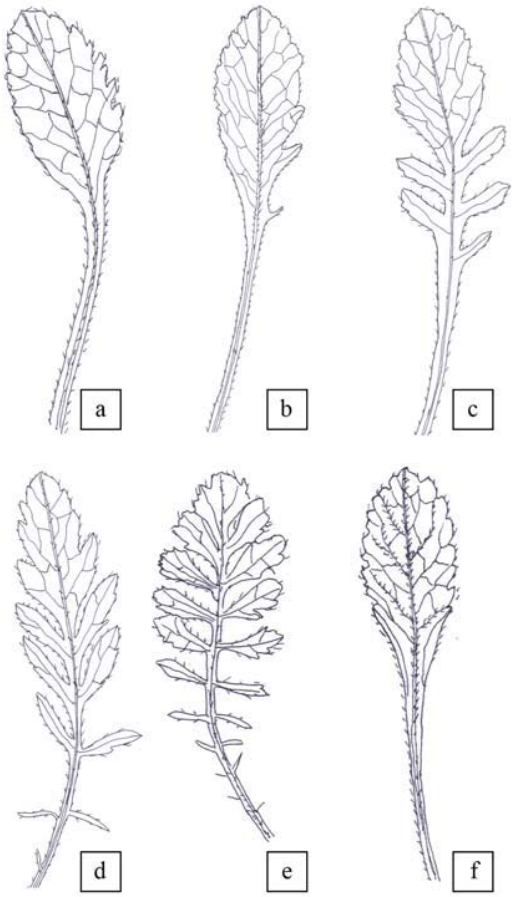

Figure 4: *Scabiosa lucida* Vill. – different forms of basal leaves
a-e) upper surface f) lower surface

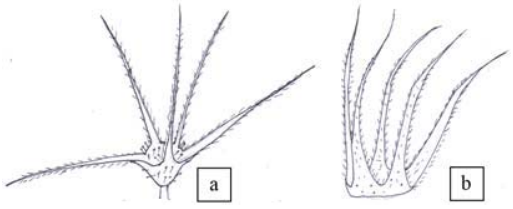

Figure 5: Calyx-setae – a) *Scabiosa columbaria* L. b) *Scabiosa lucida* Vill.

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ANALYSIS OF THE CONNECTION BETWEEN SPATIAL FACTORS WITH TWO TYPES OF FORESTS IN THE CEMERNICA FOREST MANAGEMENT UNIT, BOSNIA AND HERZEGOVINA

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ABSTRACT: The paper presents two types of forest in the area of management unit Cemernica in terms of preservation. Namely, all the forests were divided into two types, primary and modified. In the primary type we included all high forests with natural restoration, other types (coppice forests, culture...) we included in modified type. The results of the logistic regression showed what affects the position of these two types of forest. For this purpose, we included in the analysis the basic topographic variables (altitude, inclination and exposure) as well as the spatial units (the distance of the department from the settlement and the distance of the department from the nearest forest road). An analysis of the position of primary and modified parts shows that increasing the distance from the settlement increases the likelihood of the presence of primary forests, while parts of the forests that are closer to the forest roads are better preserved due to the higher traffic density in the parts of better preserved forests.
Keywords: primary forest, modified forest, logistic regression.

1 INTRODUCTION

Forests of beech, fir with spruce are most widespread in Bosnia and Herzegovina. Beech and fir with spruce community in Republic of Srpska measures the area of 21.3037 ha [10]. In the area of Cemernica, forests of beech and fir with spruce (*Piceo-Abieti-Fagetum*) represent the largest economic and ecological significance. Forest preservation is the result of human activity in the form of exploitation and care of forest stands. The reason for the deviation of the present state of the forest from the well-preserved ones is primarily the consequence of the input and expansion of conifers and other invasive species on inappropriate sites for them. Irregular shelterwood system of management is prescribed system for management in the area of Cemernica management unit [3]. Forest stands that are managed represent a typical selection structure which shows that forest stands are managed by the selection.

The extent to which the forest is preserved is linked to the forest's openness, habitat potential and historical facts. Given the current state of vegetation, growing conditions and tree species, in the area of Cemernica the following categories are present: high beech forests; mixed forests of fir and spruce; mixed forests of beech, fir and spruce; degraded beech forests; cultures of black and scots pine; low beech forests; coppice forests of sessile oak and other areas suitable and unsuitable for management. High beech forests and mixed forests of European silver fir and beech with Norway spruce cover the biggest part of Cemernica, that is 48,28 %. From economical point of view, they represent the most important and best preserved forests. According to the data from FAO classification [2] forest stands are divided into: primary, modified natural, semi-natural, productive plantation, protective.

High beech forests; pure stands and mixed stands of fir and spruce; mixed forests of beech and fir and spruce are marked as primary. Other parts of management unit are classified into group of modified forests. A smaller number of research was done on a similar topic. Bončina and others [5] analyzed the connection of salvage cutting with orography factors during period of 1979-2006, after natural disasters (wind, snow and insect's invasion). The correlation on Pokljuka on the area of 9627 ha is shown.

The works shows the following: If there is a connection between primary and modified parts of management unit with basic topographic and environmental factors: Openness with forest roads and topography (altitude, inclination and exposition)?!.

2 MATERIAL AND METHODS

2.1 Study area

Management unit Cemernica is located in the middle part of Republic of Srpska (Figure 1). It spreads from 44^0 27' 09'' to 44^0 34' 44'' north latitude. Total area of management unit is 12.353 ha. According to the forest management division, management unit Cemernica belongs to forest- management area of Cemernicko. Research area is located on altitude of 240 to 1339 m [7]. The terrain is very diverse. Most of the areas are with inclination exceeding 50 %. Those are the parts around Velika and Mala Cemernica and parts around bank of river Vrbas.

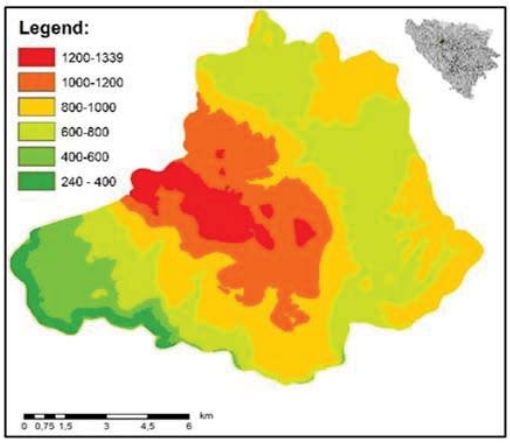

Figure 1: Location of the research area and altitude

According to ecological zoning of vegetation of Bosnia and Herzegovina [9], Cemernica is located within Knezevo area, western Bosnia limestone-dolomite area and area of the inner Dinarides. Cemernica can be considered as a typical Dinaric mountain in the geological sense. The mountain is entirely chalk formation. The pedogenetic strings that are present on the limestone are orthent-kalkomelanosol-kalkokambisol- luvisol [4].

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Table I: Variables used for modelling (primary-0; modified-1)

	Variable	Variable type	Description of the variable	Candidates for modelling
Site-characteristic variables	INC	continuous	Inclination (˚)	-
	ELV	continuous	Elevation (m)	-
	ASP	continuous	Aspect	included
	DFR	continuous	Density of forest road (m)	-
	DFP	continuous	Distance from the populated place (m)	included
	DRR	continuous	Distance from the forest road (m)	included
Past events	PAM	0/1	0 – primary forests 1 - modified forests	included

2.2 Method and analysis

The connection between primary and modified parts of management unit Cemernica from the point of view of topography (altitude, inclination and exposition) and spatial units (traffic density, distance to the settlement and distance to the nearest truck road) (Figure 2) were analyzed with logistic regression analysis [1]. All the variables analyzed were obtained at departmental level.

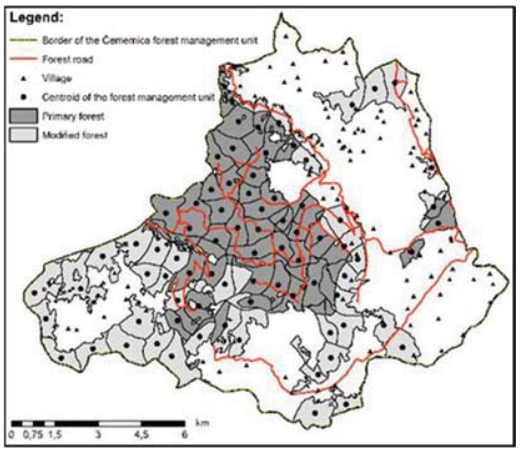

Figure 2: Research area

Topographic data were got from DEM (digital terrain models) with resolution 30 x 30 m. For each department we calculated: average elevation ELV (m); average inclination INC (0); exposure ASP (flat, N, NE, E, SE, S, SW, W, NW). The analysis included the following environment data: density of roads DFR (m/ha); distance from populated places DFP (m); distance from the forest roads DRR (m). These variables were calculated by using the programme package ArcGis 10.4.1.

In the first step, we calculated the density of the forest truck roads for each department separately. The second phase was determining centroid of each department on the map. We calculated the distance of the nearest road to the centroid of each department. In the third phase, we made a new layer with marked settlements in the management unit of Cemernica.

In this example we also calculated the distance of the nearest settlement to the centroid of the department. As a variable, in the binary logistic regression analysis we included two types of forests in relation to the preservation (0-primary; 1- modified).

Primary forests include high beech forests, pure and mixed forests of fir and spruce, and mixed forests of beech, fir and spruce. Other parts of Cemernica, such as coppice forest, forest culture and degraded forests were included into modified ones.

At the very beginning of the analysis we excluded some of the variables from analysis, due to the emergence of multilinearity. We checked this with correlation analysis. All variables that had less *Spearman's coefficient* from 0,6 were included into analysis. In this example we excluded altitude and the density of forest roads. With a t-test, we checked whether there was multilinearity between other variables. We excluded inclination from further analysis. Other variables (Table I) are included in binary logistic regression.

3 RESULTS AND DISCUSSION

The results showed that the best-preserved parts occupy about 48 % of the entire area of the management unit of Cemernica. These are primarily high beech forests, as well as pure and mixed forest stands of beech, fir and spruce. Other parts of the management unit occupy 52 % of the area. Forest cultures, coppice forests and other areas that are suitable and unsuitable for afforestation were classified into another form of forest stands that is modified forests.

Growing stock is one of the important indicators that shows us the productivity and the quality of the stands. Namely, high forests have more stocks compared to other breeding forms. In the research area of Cemernica according to the data from the forestry base for 2008, the average growing stock for high forests is 410 m3/ha and for other breeding forms 322 m3/ha. In this example, we can confirm that the high forests are better preserved than other categories. The reason for bigger area is that in that part of the management unit there are also parts especially in the southern part that are inaccessible for management due to the field configuration itself.

With logistic regression analysis, we checked whether the extent of forest preservation depends on accessibility (density of forest roads, distance to the nearest road and settlement) and topographic scale (altitude, inclination and exposition). In terms of preservation, we distinguished two types: primary (0) and modified (1). Results show that only two variables are statistically significant ($p < 0,05$). These are the distance of the department to the nearest forest road and the distance of the department to the nearest settlement.

Table II: Results of logistic regression

Variables		β	Wald Chi-Square	p
INC	Inclination	-	-	-
ELV	Elevation	-	-	-
ASP	Aspect	-0,2505	0,082	,774
DFR	Density of forest road	-	-	-
DFP	Distance from the populated place	-0,0013	8,893	,003
DRR	Distance from the forest road	0,0028	5,876	,015

All other variables were excluded from the analysis due to the occurrence of multicollinearity. The values of the regression coefficients are shown in Table II.

For an independent variable, the distance of the departments from the settlement (DFR), the value of the beta coefficient is (β = *- 0,0013*). The negative value of the regression coefficient means that increasing the distances of the settlements from the departments increases the probability of occurrence of the protected forests that is primary categories. As for the proximity of the forest roads (DRR) to the department, the results are slightly different. In this example, the values of the beta coefficient are positive ($\beta = 0.0028$), which means that the parts of the management unit Cemernica that are closer to the forest paths are better preserved.

The analysis showed that two variables (the distance of the departments from the settlement and the distance of the departments from the forest roads) significantly influenced the occurrence of unexplored forests (forest culture, coppice forest, etc.), while the other analyzed variables were not statistically significant. We showed in Table II that by increasing the distance from the settlement and the probability for the presence of the protected forests increases as well. Naturally, at a greater distance from the settlement, the intensity of the forest use by the inhabitants is lower. The improper use of the forest in this example is taken over by professional foresters. The parts of the management unit that are closer to the forest roads are surprisingly better preserved. The reason for this is that the density of the forest roads in the areas where the protected forests are located is bigger.

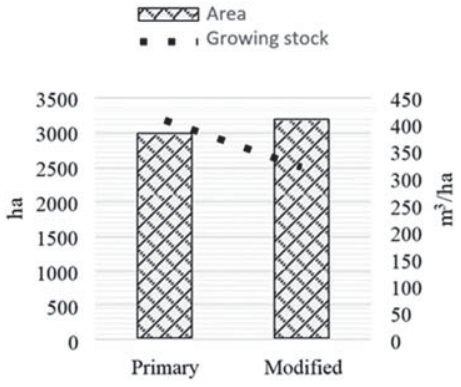

Figure 3: Growing stock and research area

4 CONCLUSION

- 48 % of the area of Cemernica management unit is occupied by category of primary forests that include high forests of beech, fir and spruce. The average growing stock of these forests is 410 m3/ha.
- Other parts marked as modified parts occupy 52 % of total area of management unit.
- The results showed that only two variables affect the presence of primary forests, that is the distance of the departments from the settlements and the distance of the departments from the forest roads.
- Bigger distance of the settlement from the department positively affects the presence of better protected forests. The reason for this is the lower intensity of the utilization of the forest by the inhabitants.
- The distance of the departments from the forest roads slightly differently influenced preservation of the forest stands. Even though the stands that are farther away from the roads should be better preserved, the results of the analysis are the opposite. The reason for this is the higher density of roads on parts of forest stands that are better preserved.

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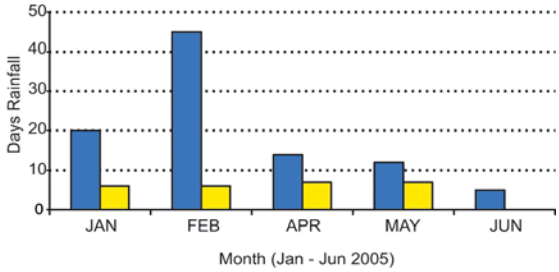

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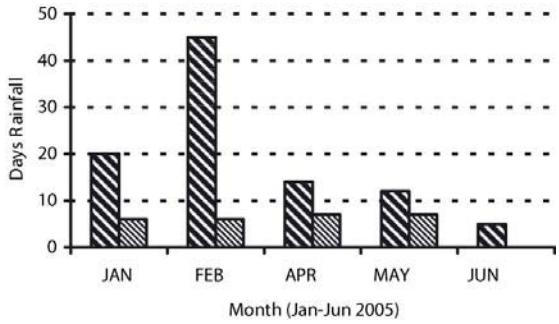

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Table I: Overview of biomass resources available

Biomass Sources	Quantity	Moisture	Residue
Sewage Sludge	1.86	1.73	1.40
Septage	0.32	0.28	0.16
Fruit Pulp	3.78	3.89	4.02

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