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

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

ШУМАРСКИ ПРЕГЛЕД
FOREST REVIEW

МЕЃУНАРОДНО НАУЧНО СПИСАНИЕ
INTERNATIONAL SCIENTIFIC JOURNAL

Шум. преглед (Šum. pregled)	Год. 45	Стр. 1-36	Скопје, 2014
For. review	Vol. 45	Pag. 1-36	Skopje, 2014

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

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

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Меѓународно научно списание	International Scientific Journal
Год. 45 / Стр. 1-36	Vol. 45 / Pag. 1-36
Скопје, 2014	Skopje, 2014
Online ISSN 1857-9507	Online ISSN 1857-9507
УДК 630	UDC 630
УДК 635.9	UDC 635.9
УДК 674	UDC 674
Издавач	**Publisher**
Универзитет „Св. Кирил и Методиј“ во Скопје	Ss. Cyril and Methodius University in Skopje
Шумарски факултет во Скопје	Faculty of Forestry in Skopje
Декан	Dean
Д-р Јане Ацевски	Jane Acevski PhD

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

ШУМАРСКИ ПРЕГЛЕД | **FOREST REVIEW**
Меѓународно научно списание | International Scientific Journal
Год. 45 / Стр. 1-36 | Vol. 45 / Pag. 1-36
Скопје, 2014 | Skopje, 2014

Online ISSN 1857-9507 | Online ISSN 1857-9507
УДК 630 | UDC 630
УДК 635.9 | UDC 635.9
УДК 674 | UDC 674

Интернет-страница | **Web page (on-line)**
www.sf.ukim.edu.mk/sumarski_pregled.htm | www.sf.ukim.edu.mk/sumarski_pregled.htm

Адреса на издавачот | **Publisher's address**
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www.sf.ukim.edu.mk | www.sf.ukim.edu.mk

For. review 45: 1-36. Skopje, 2014
Ss. Cyril and Methodius University in Skopje
Faculty of Forestry in Skopje
ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

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PREFACE

Dear Colleagues and Readers,

It is our pleasure to announce the online publication of the 45^{th} *volume of Forest Review.*

Since 1953, we had an excellent cooperation, particularly with the faculties of forestry from the Balkan and South-eastern European countries. Next year we will try to gather authors from many European countries. Beside the upload with ISSN online, we have made efforts to print this volume in hardcopy.

In this issue we have published articles from Macedonia, but we are more than certain that the next edition will be more diverse. Articles treat different forest-based issues, and are peer-reviewed by significant forestry authorities from different countries.

As we mentioned, next 2015 will be a special year because we celebrate one great jubilee - 80 years of Prof. Dr. Radoslav Rizovski's birth. We will be especially interested in articles concerning vegetation, flora and dendrology. It would be an honour for us if you have interest to participate!

Many thanks to all authors and members of the Forest Review, as well as to all peer – reviewers for the participation in this volume.

On behalf of the Editorial Board,

Asst. Prof. Bojan Simovski PhD, Editor-in-Chief

For. review 45: 1-8. Skopje, 2014

ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm
UDC: 630*231:582.477(497.712)
Original scientific article

EMERGENCE OF NATURAL REGENERATION OF ARIZONA CYPRESS (*CUPRESSUS ARIZONICA* GREENE) IN BURNT AREAS AT THE LOCALITY "MILADINOVCI" IN SKOPJE

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

ABSTRACT: This paper presents the results of the research on the emergence of the natural regeneration of the *Cupressus arizonica* Greene on completely burnt forest areas in the Miladinovci site – Skopje. These areas were afforested with *C. arizonica* Greene and black pines in 1977 and they successfully developed until the fire. The high forest fire in 2013 burnt 94% of the trees on a total surface area of 766.5 ha. In the following two years natural regeneration of the *C. arizonica* was notable in close proximity to the parent plantations. This paper presents the research on the emergence of natural regeneration of *C. arizonica* in the seedling development phase, as well as the qualitative and quantitative characteristics of regeneration unitsin different locations of the burned areas. The results of the research indicate that as a result of the fire and the burning of the plantations of *C. arizonica*, there is the appearance of natural regeneration in large numbers and of good quality. This situation leads to a successful natural regeneration of *C. arizonica* in the burnt forest areas.
Keywords: *Cupressus arizonica* Greene, natural regeneration, forest areas, forest fire.

1 INTRODUCTION

Afforestation of barren lands in Macedonia has decades of tradition. Especially intensive activities were performed in the 1965-1980 period, when different forest plants of various tree species were planted on large areas in Macedonia. Besides seedlings of indigenous tree species, non-indigenous tree species were also planted. The central parts of Macedonia were a particular challenge for afforestation, since these parts have less favorable natural conditions for the development of forest vegetation and the soils are shallow and poor. That is why afforestation was conducted primarily with non-indigenous tree species, including the *C. arizonica*. Thus, forest plantsof *C. arizonica* have been planted in multiple sites in Macedonia, such as: the Gevgelija, Negotino, Veles, and Skopje regions. The aim of theseafforestation measureswas to find the most favorable tree species which according to their bio-ecological features best suit the needs for afforestation of arid areas in Macedonia. However, for the ultimate success of the afforestations performed, monitoring and implementation of protective and growing measures was also necessary. Several researchers have dealt with the results of the performed afforestations in Macedonia and the regeneration of burned forests: Andonovski&Bebekoski (1989); Kamilovski&Nikolov (1989); Kolevska&Velkovski (2009); Popovski (1989, 2000); Velkovski *et al.*, (2008, 2012); Petrova (2015) and others who have made a contribution to the enrichment of data on the development of thisnon-indigenous species in Macedonia. *C. arizonica*, originally from Arizona (USA), as a species with a wide ecological adaptability, has been used for afforestation of bare lands in most Mediterranean European countries (Portugal, Spain, Italy, Greece, Macedonia, etc.). Its resistance to low winter temperatures and the strongly developed and adjustable root system, as well as the rapid growth makes this species suitable for afforestation in arid and eroded areas. First afforestations of this kind in Macedonia were conducted in 1968 on the territory of Negorci and then in 1972 in the Veles and Negotino regions, where acceptance of the *C. arizonica* seedlings ranged between 80 and 96% (Popovski 1989). In the period between 1972 and 1980 *C. arizonica* forest plants were planted in several other areas, including in the Skopje region. The ability of *C. arizonica* for intensive growth in early youth, high resistance to drought and low winter temperatures, good resistance against pests and phytopathological diseases was the reason for the planting of a number of *C. arizonica* forest plantsin arid areas in central Macedonia. Early and rich production of quality seeds from the 11th year was the reason for collection of seeds for seedling production of *C. arizonica*. The average number of seeds in a cone is 46-112, but the most prevalent cones have 50-60 seeds, which means that in the bottom of every cone shell there is an average of 6-14 seeds (Popovski 2000). The seeds of the *C. arizonica* show significant germination in the conditions present in Macedonia. Thus the seeds collected from *C. arizonica* in Goceva Gora around Negotino showed average laboratory germination of 26.67 to 37.15% while the seeds collected from certain trees showed even up to 89%, which represents a very high percentage for this species (Popovski 1989). The average germination of seeds from *C. arizonica* is greater than the average germination of seeds in Arizona, which amounts to 30.4% (Toumey&Korstian 1952).

C. arizonica forests in the area of Goceva Gora around Negotino already began providing seeds even at the age of 12-15, abundantly and each year providing seeds with high quality properties (Popovski 1989). The average energy of germination (germination for 13 days) ranges from 17.48 to 23.67%, which represents a high value and is proof of the great vitality of *C. arizonica* seeds (Popovski 1989).

In the Miladinovci site – Skopje region, *C. arizonica* plant ssubject of this research were planted in 1977 on a surface area of 821.80 hectares. Afforestation was performed by planting in previously prepared furrows and rows with a distance of 2.5 to 3.5 m between two rows and distance between seedlings in a row of 2 to 2.5 m. In the same plantations, certain growing measures were performed in the past for protection of young plantations, filling and trimming the branches, and in some places spacing was performedwith lower intensity. Before the fire, the plantations planted artificially were well developed and adapted to the conditions of the place of vegetation (Fig. 1 and Fig. 2).

Figure 1, 2: Un-burnt plantations of *Cupressus arizonica*

Figure 3, 4: Burnt plantations of *Cupressus arizonica*

Until the fire (6th until 10th September, 2013) the parent plantations had the age of 38 years and height of up to 15 m and with diameter at breast height of 14cm. The reason for the fire was the burning of stubbles in the neighboring Kumanovo region. The fire was high and burned 94% of the trees on a total surface area of 766.50 ha (Fig. 3 and Fig. 4).

After the fire, in 2014 a sanitary cutting of the burnt trees was performed and forest order was introduced. Such activities contributed to the improvement of the conditions for natural regeneration of the burnt areas.

Thick offspring of *Cupressus arizonica* appeared in a major portion of the burnt areas in 2014 and 2015 (Fig. 5 and Fig. 6).

Figure 5, 6: Natural regeneration of *Cupressus arizonica* of 1 and 2 years

The emergence of natural regeneration of *C. arizonica* in the burnt areas in the first and second years is remarkable and in great numbers, especially near the parent trees of the burnt plantation. Forest fires, in addition to the damage they cause, often cause the emergence of offspring in some species of forest trees, especially those whose seed is located in the cone, which due to certain reasons is difficult to open naturally (some three-spike pines, cypresses, species of *fam. Leguminoseae*, etc.). The forest fire, i.e. the high temperatures that develop, act as a strong incentive for the opening of cones or fruits and weakeningof the seed coating (Kolevska&Velkovski 2009). The impact of high temperatures on the release of seeds from cones and mass offspring emergence of *C. arizonica* was observed in the burnt areas in theGevgelija region (Kolevska&Velkovski 2009).

Artificial foreststands of coniferous species fall into the category of most vulnerable forest areas regarding wildfire. Damages incurred as a result of the fires are multiple and have long-lasting consequences. As a result of fire in artificial forest stands and depending on the amount of combustible material there is total destruction of the fragile physical-mechanical and chemical properties of the soil. The soil dries, cracks and the entire micro fauna in the solum (surface and subsoil layer) is destroyed which is why it remains sterile. Given that bare areas are usually shallow soils, in case of fire they are quickly washed and active processes of erosion occur due to which the subsoil appears on the surface (Kamilovski&Nikolov 1989).

2 INVESTIGATION AREA AND METHOD

For the purposes of obtaining relevant data on the emergence of a natural regeneration of the *C. arizonica* in the burnt areas of the "Miladinovci site in Skopje, 11 trial areas sizedfrom 2 to 4 m² were analyzed. The trials areas were located at representative locations in order to reflect the real situation of the natural regeneration of the plantation.

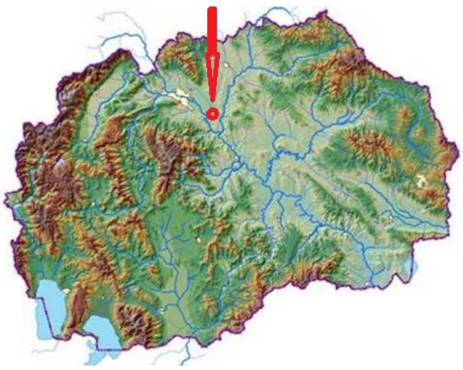


Figure 7: Location of the investigation area

Detailed measurements of the height in cm and the thickness of root neck in mm were made for all units in the trial areas. All measured units were grouped according to the methodology of Šafar (1958), in two developmental stages: (1) undeveloped seedling with height of 0.30 cm and (2) developed seedling with a height between 0.30 and 1.30 cm. In addition, all individuals in the trial areas were assessed by their quality and vitality in three groups according to the following features:

- Group 1: (Good). This group includes all the individualsthat are healthy and vital, with upright stem and well developed canopy.
- Group 2: (Medium). This group includes all the individuals that are healthy and have good quality features, but are lagging in their development behind those in the first category.
- Group 3: (Poor). Covers all the individuals with poor quality and poor vitality, crooked stem and irregularly distributed canopy and poor health condition or are far behind the others in their development.

An analysis was made using the collected data which determined their height, thickness and quality structure. The abundance of natural regeneration is calculated per 1 hectare so that the number of the regeneration is the quotient of the product of the number of individuals in the trial area contained in one hectare and the size of the trial area. The appropriate conclusions were drawn from the estimates and analyzes.

Figure 8, 9: Trial areas for data collection (and estimation) of natural regeneration

3 RESULTS AND DISCUSSION

Large areas under bare and eroded lands, unproductive forest areas overgrown with bushes, shrubbery and other degradation forms of vegetation that can be found in Macedonia, especially in its central parts, were the reason to carry out afforestations with different species of trees. Simultaneously, introduction was also made of non-indigenous species that originate from areas with similar natural characteristics and have a strong environmental adaptability such as the *C. arizonica*. Such afforestations and still present and the results of the preceding afforestations and researches are useful for planning further measures and activities for achieving better results in silvicultural practices.

The results from the researches on the occurrence of natural regeneration of *C. arizonica* in the area of Miladinovci contribute towards enriching the information base regarding the use of this type and its natural potentials for regeneration, which become prominent after a forest fire.

Table I contains values on the abundance of the natural regeneration within two years, for each trial area according to its exposition and altitude, as well as data on the heights and diameters of the natural regeneration individuals.

For. review 45: 1-8. Skopje, 2014
Ss. Cyril and Methodius University in Skopje
Faculty of Forestry in Skopje ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

Table I: Number of individuals of *Cupressus arizonica*

Sample plot (SP)	Total individuals per 1ha	Height (cm)	Diameter (mm)	Exposition	Altitude (m)	Coordinates
1	1 020 000	29.1	2.6	SW	368	E00557649 N04648121
2	885 000	35.9	3.1	SW	375	E00557661 N04648096
3	550 000	38.4	3.5	S	378	E00557638 N04648112
4	60 000	55.4	8.6	E	389	E00556262 N04648970
5	185 000	32.4	3.3	N	398	E00556190 N04649047
6	210 000	32.6	3.7	S	371	E00557655 N04648103
7	365 000	16.5	2.0	W	375	E00557689 N04648103
8	135 000	26.9	3.4	E	391	E00556226 N04648985
9	195 000	20.3	2.1	NE	396	E00556218 N04649003
10	175 000	30.3	2.8	Flat terrain	386	E00556241 N04649005
11	125 000	44.8	5.6	Flat terrain	392	E00556263 N04649013
Average	355 000	32.9	3.7			

It can be seen from the data given in Table I, that the frequency of the natural regeneration of *C. arizonica*is ranging between 60 000 and 1 020 000 individuals per 1 ha, or in average, there are 355 000 individuals per 1 ha. The abundance of the natural regeneration is the highest in the areas on Southeastern exposition, from 885 000 to 1 020 000 individuals/ha, and the lowest on East exposition, from 60 000 to 135 000 individuals/ha. The medium height of the natural regeneration (individuals) is ranging between 16.5 cm in SP-7, located on West exposition up to 55.4 cm in SP-4, located on East exposition, or 32.9cm in average. The mean values of the individual's base thickness are ranging from 2.0 in SP-7 to 8.6 mm in SP-4, or the mean thickness is 3.7 cm. Often in the science and in practice is determined that the types introduced from some more distant areas of particular territories produce better results than some types of indigenous trees or species that have closer distribution areas. Thus, it has been determined at Choloshovski Rid – Veles area that the *C. arizonica* has reached a diameter of 1.30m from the initial 12.71cm, medium height of 6.93m and mean annual growth of 5.28m^3 in the 15th year of age, while the black pine raised on the same place, had a diameter at breast height of 7.58cm, medium height of 4,44m and average annual growth of 1.32m^3 (Andonovski&Bebekoski 1989). The 9 years old *C. arizonica* inartificial forest standsin Negotino and Veles has a medium height ranging from 326.2 cm to 414.7 cm and medium diameter at breast height from 4.5 cm to 6.7 cm (Popovski&Stamenkov 1989).

Taking into consideration that the natural regenerationis 2 years old and the individuals have various height and quality features, according to the Šafar methodology, they have been divided into: (1) undeveloped seedling (h<30 cm), which covers the units with height less than 30 cm and (2) developed seedling (h>30<130 cm), which covers the units with height from 30 cm to 130 cm. The results obtained from the conducted measurements of the abundance, quality and the growth stadium of the natural regeneration, as well as the exposure of each of the trial areas are given in the following tables.

From the data on the natural regeneration on Southwestern exposition given in Table II can be seen that 45.4% of the individuals are in the growth stadium of undeveloped seedling, while 54.6% are in the growth stadium of developed seedling. Out of the total number of individuals, 21.5% have good quality, 43.8% have medium quality and 34.7% have bad quality.

It can be seen from the data on the natural regeneration on South exposition, given in Table III, that 33.2% of the individuals are in the growth stadium of undeveloped seedling, while 66.8% are in the growth stadium of developed seedling. Out of the total number of individuals, 19.7% have good quality, 44.7% have medium quality and 35.6% have bad quality.

It can be seen from the data on the natural regeneration on East exposition, given in Table IV, that 46.2% of the individuals are in the growth stadium of undeveloped seedling, while 53.8% of the individuals are in the growth stadium of developed seedling. Out of the total number of individuals, 25.6% have good quality, 39.7% have medium quality and 34.7% have bad quality.

From the data on the natural regeneration on flat terrain, given in Table V can be seen that 38.3% of the individuals are in the growth stadium of undeveloped seedling, and 61.7% are in the growth stadium of developed seedling. Out of the total number of individuals, 22.5% have good quality, 40.0% have medium quality of 37.5% have bad quality.

Table II: Abundance, quality and growth stadium of the natural regeneration on Southwestern exposition

Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
SP-1								
h< 30 cm	20 000	8.0	270 000	64.3	330 000	94.3	620 000	60.8
h>30< 130 cm	230 000	92.0	150 000	35.7	20 000	5.7	400 000	39.2
Total	**250 000**	**24.5**	**420 000**	**41.2**	**350 000**	**34.3**	**1 020 000**	**100.0**
SP-2								
h< 30 cm	0	0.0	35 000	8.4	210 000	67.7	245 000	27.7
h>30< 130 cm	160 000	100.0	380 000	91.6	100 000	32.3	640 000	72.3
Total	**160 000**	**18.1**	**415 000**	**46.9**	**310 000**	**35.0**	**885 000**	**100.0**
SP1+ SP2:2								
h< 30 cm	10 000	4.9	152 500	36.5	270 000	81.8	432 500	45.4
h>30< 130 cm	195 000	95.1	265 000	63.5	60 000	18.2	520 000	54.6
Average	**205 000**	**100**	**417 500**	**100**	**330 000**	**100**	**952 500**	**100**
	21.5		**43.8**		**34.7**		**100**	

Table III: Abundance, quality and growth stadium of the natural regeneration on South exposition

Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
SP-3								
h< 30 cm	0	0,0	30 000	12.5	130 000	61.9	160 000	29.1
h>30< 130 cm	100 000	100.0	210 000	87.5	80 000	38.1	390 000	70.9
Total	**100 000**	**18.2**	**240 000**	**43.6**	**210 000**	**38.2**	**550 000**	**100,0**
SP-6								
h< 30 cm	0	0.0	37 500	37.5	55 000	91.7	92 500	44.0
h>30< 130 cm	50 000	100.0	62 500	62.5	5 000	8.3	117 500	56.0
Total	**50 000**	**23.8**	**100 000**	**47.6**	**60 000**	**28.6**	**210 000**	**100.0**
SP3+SP6 :2								
h< 30 cm	0	0	33 750	19.9	92 500	68.5	126 250	33.2
h>30< 130 cm	75 000	100.0	136 250	80.1	42 500	31.5	253 750	66.8
Average	**75 000**	**100**	**170 000**	**100**	**135 000**	**100**	**380 000**	**100**
	19.7		**44.7**		**35,6**		**100**	

Table IV: Abundance, quality and growth stadium of the natural regeneration on East exposition

Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
SP-4								
h< 30 cm	0	0.0	0	0.0	0	0.0	0	0.0
h>30< 130 cm	17 500	100.0	25 000	100.0	17 500	100.0	60 000	100.0
Total	**17 500**	**29.2**	**25 000**	**41.6**	**17 500**	**29.2**	**60 000**	**100.0**
SP-8								
h< 30 cm	2 500	7.7	37 500	71.4	50 000	100.0	90 000	66.7
h>30< 130 cm	30 000	92.3	15 000	28.6	0	0	45 000	33.3
Total	**32 500**	**24.1**	**52 500**	**38.9**	**50 000**	**37.0**	**135 000**	**100.0**
SP4+SP8 :2								
h< 30 cm	1 250	5.0	18 750	48.4	25 000	74.1	45 000	46.2
h>30< 130 cm	23 750	95.0	20 000	51.6	8 750	25.9	52 500	53.8
Average	**25 000**	**100**	**38 750**	**100**	**33 750**	**100**	**97 500**	**100**
	25.6		**39.7**		**34.7**		**100**	

Table V: Abundance, quality and growth stadium of the natural regeneration on flat terrain

Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
SP-10								
h< 30 cm	2 500	6.3	17 500	25.0	62 500	96.2	82500	47.1
h>30< 130 cm	37 500	93.7	52 500	75.0	2 500	3.8	92500	52.9
Total	40 000	22.9	70 000	40.0	65 000	37.1	175000	100.0
SP-11								
h< 30 cm	0	0.0	2 500	5.0	30 000	63.2	32500	26.0
h>30< 130 cm	27 500	100.0	47 500	95.0	17 500	36.8	92500	74.0
Total	27 500	22.0	50 000	40.0	47 500	38.0	125000	100.0
SP10+SP11 :2								
h< 30 cm	1 250	3.7	10 000	16.7	46 250	82.2	57 500	38.3
h>30< 130 cm	32 500	96.3	50 000	83.3	10 000	1.8	92 500	61.7
Average	**33 750**	**100**	**60 000**	**100**	**56 250**	**100**	**150 000**	**100**
	22.5		**40.0**		**37.5**		**100**	

It can been seen from the data on the natural regeneration on North exposition, given in Table VI, that 45.9% of the individuals are in the growth stadium of undeveloped seedling, while 54.1% are in the growth stadium of developed seedling. Out of the total number of individuals, 17.6% have good quality, 37.8% have medium quality and 44.6% have bad quality.

It can be seen from the data on the natural regeneration on West exposition, given in Table VII, that 93.2% of the individuals are in the growth stadium of undeveloped seedling, while 6.8% are in the growth stadium of developed seedling. Out of the total number of individuals, 16.4% are with good quality, 42.5% are with medium quality and 41.1% are with bad quality.

It can be seen from the data on the natural regeneration on Northeastern exposition, given in Table VIII, that 92.3% of the individuals are in the growth stadium of undeveloped seedling, and 7.7% are in the growth stadium of developed seedling. Out of the total number of individuals, 18.0% have good quality, 42.3% have medium quality and 39.7% have bad quality.

The overall share of the natural regeneration of *C. arizonica* in the growth stadium undeveloped seedling is 54.5%, and 45.5% in the growth stadium developed seedling.

Table VI: Abundance, quality and growth stadium of the natural regeneration on North exposition

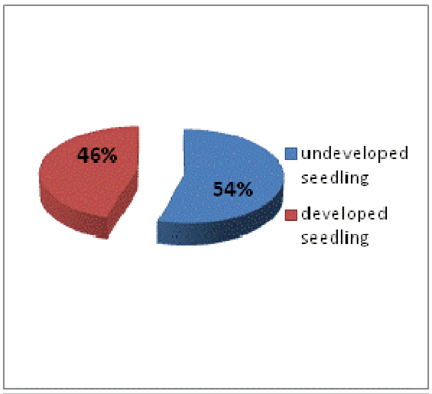
Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
h< 30 cm	0	0.0	17 500	25.0	67 500	81.8	85 000	45.9
h>30< 130 cm	32 500	100.0	52 500	75.0	15 000	18.2	100 000	54.1
Total	32 500	17.6	70 000	37.8	82 500	44.6	185 000	100.0

Table VII: Abundance, quality and growth stadium of the natural regenerationon West exposition

Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
h< 30 cm	40 000	66.7	150 000	96.8	150 000	100.0	340 000	93.2
h>30< 130 cm	20 000	33.3	5 000	3.2	0	0.0	25 000	6.8
Total	60 000	16.4	155 000	42.5	150 000	41.1	365 000	100.0

Table VIII: Abundance, quality and growth stadium of the natural regeneration on Northeastern exposition (SP10)

Quality / Growth stadium	Good		Medium		Bad		Total	
	ind/ha	%	ind/ha	%	ind/ha	%	ind/ha	%
h< 30 cm	20000	57.1	82500	100.0	77500	100.0	180000	92.3
h>30< 130 cm	15000	42.9	0	0	0	0	15000	7.7
Total	35000	18.0	82500	42.3	77500	39.7	195000	100.0



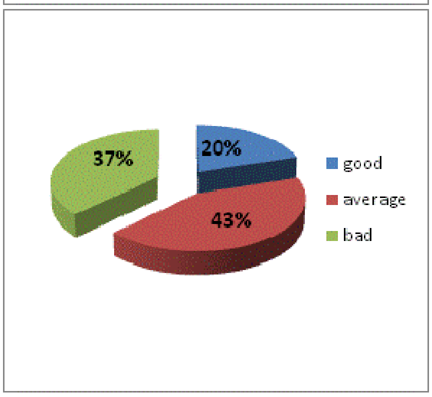


Figure 10, 11: Quality structure and growth stadium of the natural regeneration (%)

The information that a large number of individuals (45.5%) has entered the stadium of developed seedling in the second year of their growth i.e. that they are higher than 30 cm, indicates on intensive and fast growth of the *C. arizonica* in the burnt forest areas in Miladinovci. In relation to the total quality structure of the natural regeneration, 20.1% of the individuals have good quality, 42.7% have medium quality and 37.2% have bad quality. The obtained results indicate that *C. arizonica* in the examined area has strong regenerative potential which comes to the fore after occurrence of a forest fire. The heat makes cones to open and their seed to spread and form numerous natural regeneration.

5 CONCLUSIONS

Based on the obtained results from the conducted researches on the occurrence of natural regeneration of *C. arizonica* Greene on the burnt areas in Miladinovci, the following has been concluded:

The high forest fire that occurred in 2013 burnt 94% of the parent plantations at the age of 38 and height up to 15m and diameter of breast height 14 cm. Numerous natural regeneration of the *C. arizonica* has been noticed after the forest fire, varying between 60 000 to 1 020 000 individuals per 1 ha or, in average, 390 000 individuals per 1 ha. The natural regeneration is highest in the areas on South exposition, from 885 000 to 1 020 000 individuals/ha, and the lowest on East exposition, from 60 000 to 135 000 individuals/ha.

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

The overall share of the natural regeneration of *C. arizonica*in the growth stadium undeveloped seedling, is amounting to 54.5%, and 45.5% for the developed seedling. The information that a large number of individuals (45.5%) has entered the stadium of developed seedling in the second year of their growth i.e. they are higher than 30cm, indicates on intensive and fast growth of the *C. arizonica* in the burnt forest areas in Miladinovci. In relation to the total quality structure of the natural regeneration, 20.1% of the individuals have good quality, 42.7% have medium quality and 37.2% have bad quality. The obtained results indicate that the *C. arizonica*in the examined area has strong regenerative potential which comes to the fore after occurrence of a forest fire. The heat makes cones to open and their seed to spread and form numerousnatural regeneration.

The strong bio-ecological features of *C. arizonica* which successfully adapted to the unfavorable and dry growing sites at the examined area, its ability to produce quality seed which quickly develops into a seedling following a forest fire, as well as the quick development during its first years, make *C. arizonica* very competitive to the weeds and an important sort for afforestation of the dry and unfavorable terrains in Central Macedonia.

C. arizonica has great ability to regenerate naturally on burntareas; however, appropriate protection and silvicultural measures are necessary for a complete successful and proper regeneration as a support of the development of the natural regeneration.

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For. review 45: 9-16. Skopje, 2014
ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm
UDC: 582.476(497.7:23)
Original scientific article

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

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

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

1 INTRODUCTION

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

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

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

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

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

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

2 INVESTIGATION AREA AND METHOD

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

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

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

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

3 RESULTS AND DISCUSSION

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

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

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

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

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

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

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

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

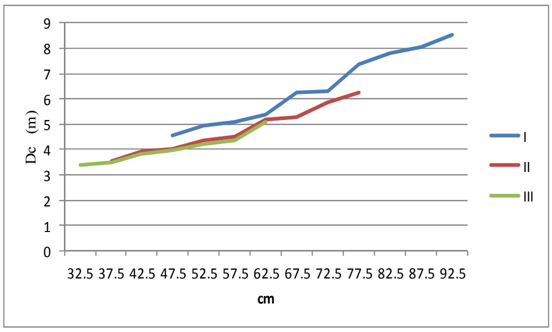

Figure 6: Mean crown diameter

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

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

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

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

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

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

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

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

Table I: Mean crown diameter

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

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

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

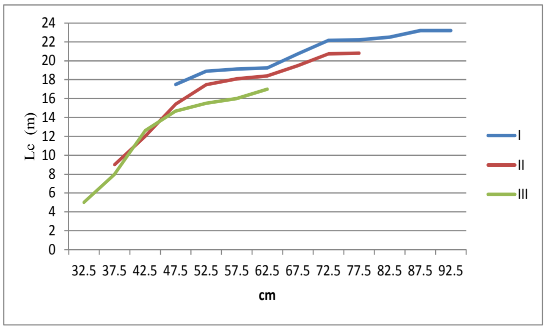

Figure 9: Absolute crown length

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

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

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

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

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

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

Table II: Absolute crown length

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

Table III: Relative crown length

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

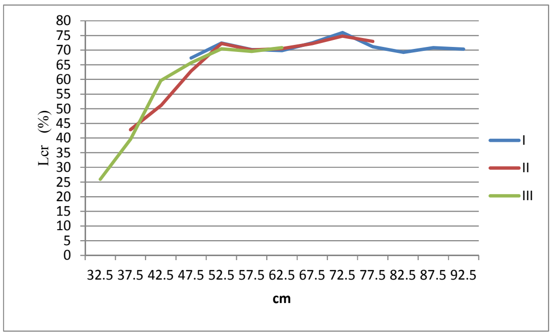

Figure 10: Relative crown length

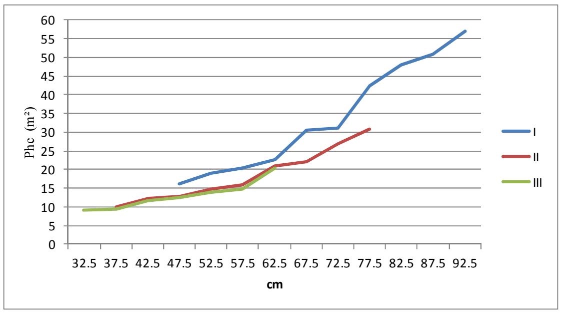

Figure 11: Horizontal crown projection

Table IV: Horizontal crown projection

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

Table V: Crown index

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

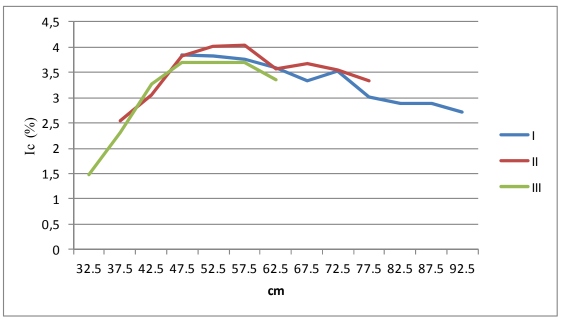

Figure 12: Crown Index

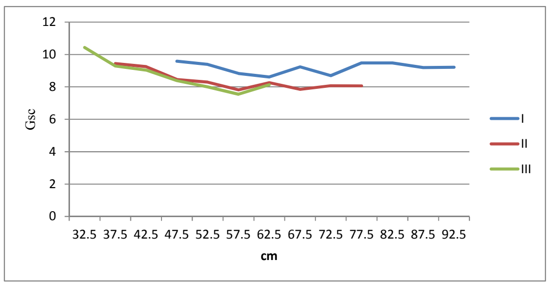

Figure 13: Growing space coefficient (quotient of crown expansion)

Table VI: Growing space coefficient

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

For. review 45: 9-16. Skopje, 2014
Ss. Cyril and Methodius University in Skopje
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ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

Table VII: Relative space for tree growth

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

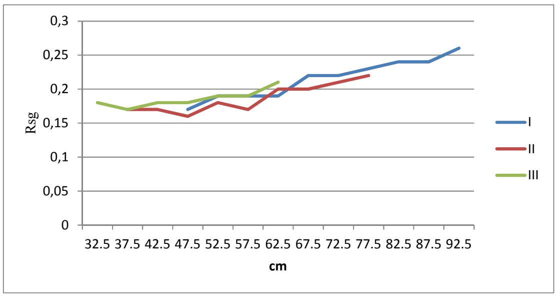

Figure 14: Ratio of the crown width and the total tree height

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

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

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

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

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

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

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

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

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

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

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

4 CONCLUSIONS

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

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

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

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

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

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

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

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

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ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm
UDC: 630*45:582.47]:632.7(497.7)
Original scientific article

THE HEALTH CONDITION OF CONIFEROUS FORESTS AND CULTURES IN R. MACEDONIA WITH A SPECIAL FOCUS ON INSECT PESTS

[1]NACHESKI S., [1]PAPAZOVA-ANAKIEVA I.
[1]*Ss. Cyril and Methodius University in Skopje, Faculty of Forestry in Skopje, Skopje, Macedonia*
Corresponding author e-mail addres: snaceski@sf.ukim.edu.mk

ABSTRACT: In the conifer stands in the Republic of Macedonia the most damaging insects are detected in the pine stands. From the large number of identified pests in the last three decades, the most significant damages were done by the following species: *Thaumetopoea pityocampa* Den. et Schiff., *Neodiprion sertifer* Geoff., *Diprion pini* L., *Rhyacionia buoliana* Den. et Schiff., *Pissodes notatus* F., *Monochamus galloprovincialis* Ol. and the bark beetles (*Hylastes linearis* Erich., *Hylastes ater* Paik., *Tomicus minor* Hart., *Tomicus piniperda* L., *Pityogenes bidentatus* Hrbst. *Pityogenes bistridentatus* Eich., *Pityogenes quadridens* Hart., *Ips sexdentatus* Boern., *Ips acuminatus* Gyll., *Ips mansfeldi* Wach. and *Ortothomicus erosus* Boern.). The pine processionary moth in the pine stands in the R. of Macedonia has been in overpopulation on a regular intervals of 4 or 5 years. Such gradation of these species were registered in 1990, 1995, 2001 and 2010, when more than 20.000 ha of pine stands were attacked. In 2009 nearly 15.000 ha and 2010 - 19.100 ha showed very high population density, with serious threats for total defoliation and possibly destruction. According to our data, the number of caterpillar nests from the generation 2015/16 ranged from 700 in the locality Kalaslari-near Veles to 22.000 per 1ha in locality Crnilishki Rid- near Sveti Nikole. From 11 bark beetle species, *Ips sexdentatus* Boern. and *Ips acuminatus* Gyll. had the highest populations in the regions near Berovo, Strumica, Kavadarci, Kochani, Delchevo, and in the regions near Sveti Nikole - *Pityogenes bistridentatus* Eich. and Bitola- *Ips sexdentatus* Boern. *Ips acuminatus* Gyll. and *Tomicus minor* Hart. The abundance of the other pest insects: *Neodiprion sertifer* Geoff., *Diprion pini* L., *Rhyacionia buoliana* Den. et Schiff., *Pissodes notatus* F., *Monochamus galloprovincialis* Ol. and *Coleophora laricella* Hb. in natural and newly planted coniferous stands in the R. of Macedonia is low.
Keywords: insects, pine processionary moth, bark beetles, larch casebearer, defoliator, population dynamics.

1 INTRODUCTION

Conifer forests in the R. Macedonia are covering an area of 791162,89 ha, of which 70812,33 ha are pure and 8350,56 ha are mixed conifer forests. Also, there are 4175,30 ha of mixed conifer–broadleaved forests (Monograph of Macedonian Forests, 2008).

Since the fifties of the last century, when the intensive afforestation of bare land began, according to Dimitrov, until 1970 there were about 60,000 ha afforested through systematic permanent programes and in the period from 1971 to 1985 another 100,000 ha were afforested. *Pinus* spp. were the most frequently used species in these afforestation projects (accounting for 95% of seedlings planted) and *Pinus nigra* Arn. as a dominant species, often in monocultures. In that period, also were used other coniferous species on the individual sites but with much smaller percentage (*Pinus silvestris* L., *Larix europea* DC, *Picea abies* (L.) H. Karst., *Pinus strobus* L., *Pseudotsuga menziesii* (Mirb.) Franco and *Chamaecyparis lawsoniana* Parl).

Natural coniferous forests as stable ecosystems are less threatened by insect pests. However, due to certain disorders of abiotic nature as uprooting by wind (windthrow, windsnap) or snow, forest fires, conifer forests become more susceptible to bark beetles and in certain regions of the Republic Macedonia they are a serious threat to the coniferous stands [1,2,3,4,10,11,12,14,18].

As opposed to them, the newly created monocultures represent poor ecosystem that still has not established a biological balance, in which we have registered the appearance of many pests and plant diseases. The most commonly recorded species are *Thaumetopoea pityocampa* Den. et Schiff., *Neodiprion sertifer* Geoff., *Diprion pini* L., *Rhyacionia buoliana* Den. et Schiff., *Pissodes notatus* F., *Monochamus galloprovincialis* Ol. and the bark beetles (Curculionidae: *Solytinae*) [5,6,7,8,15,16,17].

2 MATERIAL AND METHODS

For the realization of this research we have used standard and adapted methods for the determination of the abundance of pine processionary moth, european pine sawfly, pine bark beetles, larch casebearer, also the intensity of the attack and the degree of the damage of the needles were assessed. This investigations were performed on the stationary experimental plots in natural and newly planted coniferous stands and also in the entomological laboratory of the Faculty of Forestry in Skopje.

For this reason we have selected stationary experimental plots with dimensions of 25x25m (625m^2) in which the elements mentioned above were monitored.

- On this test surface occurrence and density of the populations of the harmful insects are monitored.
- Abundance was determined by the number of nests per pine for the *Th. pityocampa,* number of larval colonies for the *N. sertifer*, and the registration of certain stages of the development for the bark beetles.
- The intensity of the attack and the degree of development of the larvae of *Th. pityocampa* and *N. sertifer* were also determined. Eggs of pine processionary moth were collected and brought to the entomological laboratory, at the Faculty of Forestry in Skopje, to determine the percentage of parasitization.

On the locations where was observed bark beetle attacks three trees were analyzed. Also, during the research we have conducted registration of the shoots damaged due to larval feeding (folded and dried shoots) from the caterpillars of *Rh. buoliana* damaged stems from *Pissodes notatus* and defoliation from the larch moth.

3 RESULTS AND DISCUSSION

3.1 *Thaumetopoea pitiycampa* Den. et Schiff.– The pine processionary moth

Pine processionary was already recorded 50 years ago in nearly all the natural black pine stands of the Republic of Macedonia [19, 9].It was observed in the southern part of the country (Gevgelija at an elevation of 535 m a.s.l to Visoka Čuka at 1.200 m; Mariovski basen, where the main focus of infestation, to Ligurasa – Tribot Karavastina at 1200 m a.s.l) as well as in the north (from Pusta Breznica to Skopje) the Central part (it can occasionally be found near Krusevo on 1300 m a.s.l) in the east along the border (Malesevski Mountains, Golak , Plačkovica, Ograzden), and in the west to Bitola, Resen and Ohrid Region. In these natural stands, the processionary moth did not constitute particular threat because of the natural regulation of its populations, and the resulting damage is thus reduced to minimum.

But the pine processionary moth has extended to the man-made pine plantations which cover 160,000 ha, 95 % from them being black pine monocultures. At present it can be found nearly everywhere, from Gevgelija on south through the whole flow of Vardar River to Skopje; in the east at Kriva Palanka, Kratovo, Golak, Malesevski Mountains, Plackovica, and Sveti Nikole; in the west at Prilep, Resen, Ohrid, Struga occasionally in Krusevo and Brod; and a single presence is register in Demir Hisar and Kičevo Region. Presently, the most jeopardized black pine cultures are those in the regions near Vinica, Delcevo, Radoviš, Kočani, Štip, Veles, Negotino, Sveti Nikole, Bitola and Prilep [3].

Population Dynamics and Outbraking Periods in the Past. Pine proccesionary moth showed gradations in the pine stands of the Republic of Macedonia at regular intervals of 4-5 years. Thus, moth outbreaks were registered in 1990, 1995 and 1996, when more than 20,000 ha of pine stands were attacked.

The first outbreak on the large area was noticed in 1986, when 3,000 ha of pine forests were damaged in the region of Bitola. Since then, cyclical heavy infestations occurred, increasing in intensity with changes in climatic conditions. In 1992, 4500 ha became infested whilst the damaged area reached 20,000 ha in 1994. Control measures resulted in population collapse in the following years. However, in 1999, the level of infestation increased, and 26,500 ha subsequently became infested (Fig. 2).

In 2009, there was another outbreak and by May 2010 significant damage was reported. Moth monitoring using the number of larval tents revealed a critical population density in the country although annual and regional fluctuations were noticed. Moth presence was ascertained in 27 regions. During 2003-2010, the number of larval tents ranged 400-20,400 in Bitola region whilst these values varied between 460 and 19,000 in Kočani region. In 2011, nearly 8000 ha showed very high population density, with serious threats for total defoliation and possibly destruction. In this year, the number of larval tents varied from 3,400 per ha at Mirjanina crkva-Štip to 8,600 at Goceva Gora – near Negotino (Fig. 1).

Around 14,000 hectares of pine cultures were attacked from the caterpillars of pine processionary moth in 2015, from which 75.1% (10315,8 ha) were with medium to strong intensity of the attack.

Particular Biological Features Observed in the Country. Swarming and egg-laying of pine processionary moth starts by late July and lasts until the beginning of August in sites located at high elevation (700-900 m), in the Republic of Macedonia. However, these processes start 7-10 days later in sites at lower elevation (200-500m) larval development depends on the climatic conditions. In a year with mild winter (such as years 2001/2002), larval development is completed by mid-February when the larvae begin to process. By contrast, in years with cold and long winters (such as years 2011/2012) the development is delayed and only completed by mid- or late May.

Several species of egg parasitoids have been identified in Macedonia: *Ooencyrtus pityocampae, Tetrasitchus tibialis, Trichogramma semblidis* and *Trichgramma embryophagum.* Natural parasitization by these egg parasitoids only reached 13.5 % which is not enough to induce a natural regulation of moth populations in the pine plantations.

Hosts. Predominantly on *Pinus nigra*, but occasionally on *P.sylvestris, P.peuce, P. brutia, P.pinaster*, and *Pseuodotsuga menziensii.*

Expansion with Global Warming. As likely result of global warming, larval colonies were registered in 2009 for the first time at Zmiski Rid near Kumanovo as the most northern location in the country. High densities of larval tents were also observed on the 500 ha of this area in 2010.

3.2 Bark beetles (Fam. *Scolytidae /Ipidae/*)

In the last twenty years the negative influence of the bark beetles in the natural and artificial pine stands is becoming bigger [4,10,11].

The insects of the *Scolytinae* subfamily are secondary pests on the pine, but under certain favourable conditions in the forests, like for example in Berovo region in 1993, these insects may become primary. Except in Berovo, these insects were registered with overpopulation in the regions near Pehchevo, Delchevo, Kamenica, Kochani, Svetinikole, Kriva Palanka, (Novo Selo) Strumica, Prilep, Bitola and Kavadarci.

During this research 11 species of *Scolytinae* subfamily were registered (*Hylastes linearis* Erich., *Hylastes ater* Paik., *Tomicus minor* Hart., *Tomicus piniperda* L., *Pityogenes bidentatus* Hrbst. *Pityogenes bistridentatus* Eich., *Pityogenes quadridens* Hart., *Ips sexdentatus* Boern., *Ips acuminatus* Gyll., *Ips mansfeldi* Wach. and *Ortothomicus erosus* Boern.) with regular occurrence in the pine forests. From these species *I.acuminatus* and *I. sexdentatus*, had the highest populations in the regions near Berovo, Kamenica, Kochani, Kriva Palanka and Prilep, in the Sveti Nikole region – *P. bistridentatus* and *P. bidentatus*, in the Veles region – *P. bistridentatus* and *I. mansfeldi*, in the Bitola region – *T minor* and near Delchevo – *I. sexdentatus* Boern.

Over 3500 ha of white and black pine forests were attacked by the bark beetles in 2015 in the Republic of Macedonia (fig.3). Regions most affected by beetles in 2015 are: Kochani, Kamenica, Kriva Palanka, Kratovo, Bitola, Berovo, Pehcevo, Strumica and Prilep. Control measures are required to prevent their gradation in the spring 2016.

In the future investigation, bigger attention will be given to the biological and biotechnological means of the suppression.

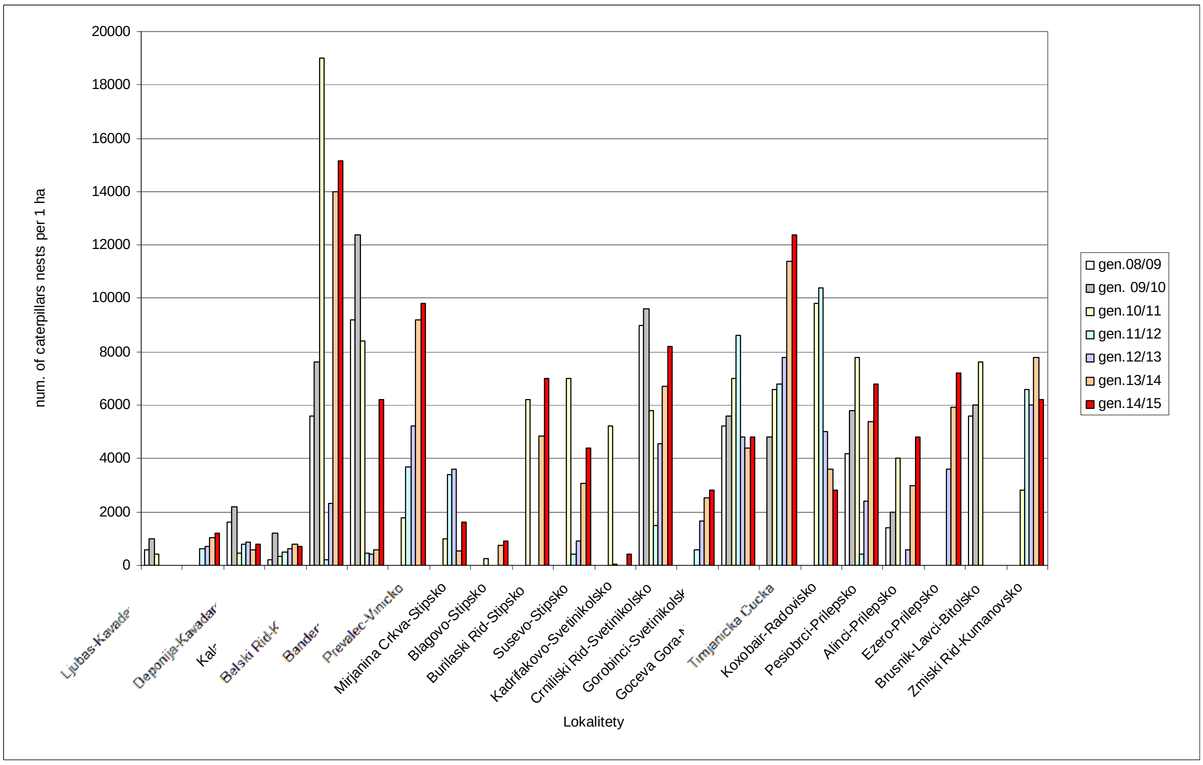

Figure 1: Abundance of the pine processionary moth from 2008-2015 in R. Macedonia (number of caterpillar nests per 1ha)

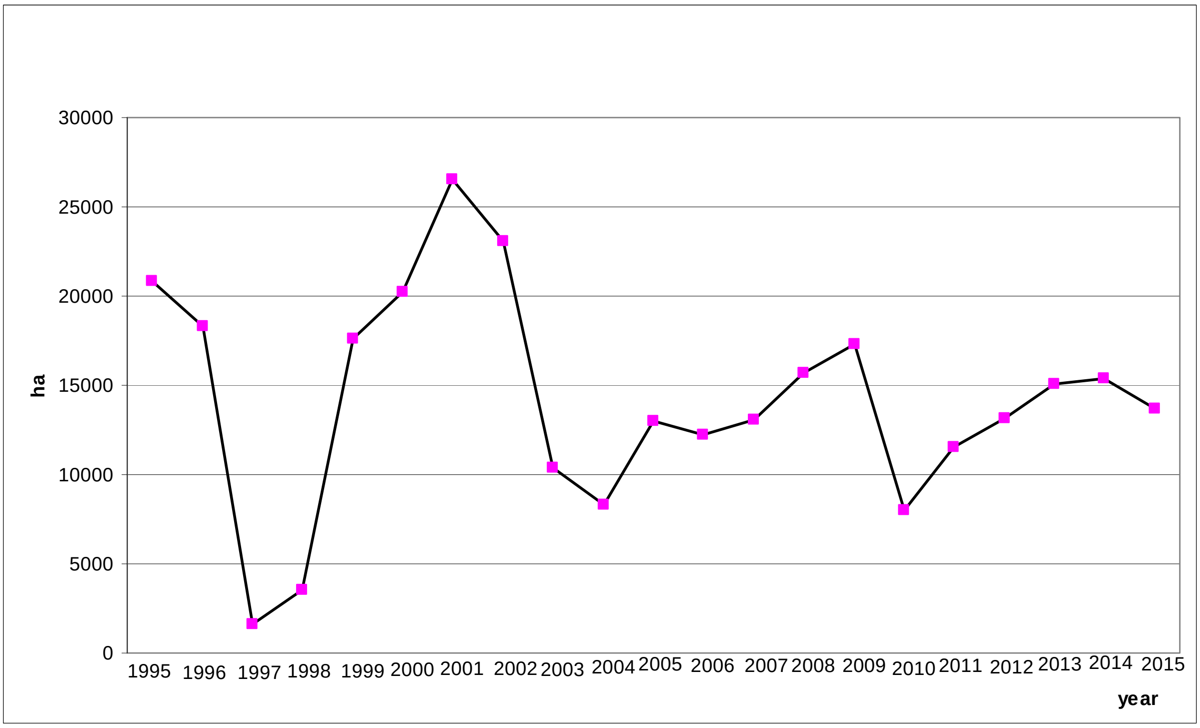

Figure 2: Surface area under attack of the pine processionary in R. Macedonia in the period from 1995-2015

We need detailed research of the ecological factors which have the most influence on the population abundance of these pests, in order to be used as a natural regulator of the abundance.

3.3 *Neodiprion sertifer* Geoffr.- The European pine sawfly

Neodiprion sertifer Geoffr. represents a harmful insect that is constantly present in cultures of black pine in the regions near Skopje, Kumano, Sveti Nikole, Veles, Negotino and Prilep.

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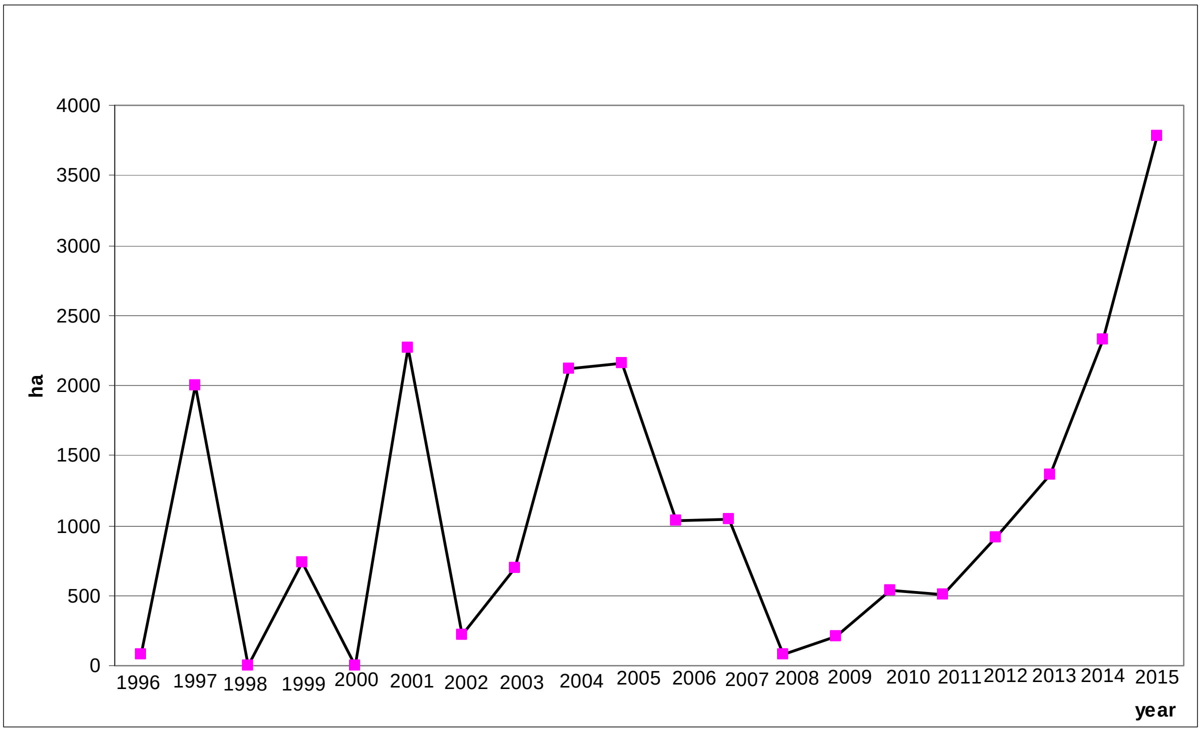

Figure 3: Surface area under attack of the bark beetles (subfam. *Scolytinae*) in R. Macedonia in the period from 1995-2015

Figure 4: Surface area under attack of *Neodiprion sertifer* in R. Macedonia in the period from 1995-2015

Its last gradation was registered in 2005 when aviosuppression were performed on 500 ha of black pine cultures in Miladinovci – near Skopje and Pchinja and Vakav - near Kumanovo, whith good results.

In untreated pine cultures in 2006 abundance of *N. sertifer* continued to grow (also in other cultures such as in Veles and Kumanovo regions, where attack was rated with high intensity, which had total defoliation).

During the year 2008 attacked area of pine stands by *N. sertifer* was 1205 ha. In the next years the attacked area by *N. sertifer* was 1014 ha in 2009; 656 ha in 2010, 886 ha in 2011, 501 ha in 2012, 870 ha in 2013, 832 ha in 2014 ha and 767.5 ha in 2015. In some microlocalities we have observed progradation, which in 2015 had the retrogradation trend (Fig. 4).

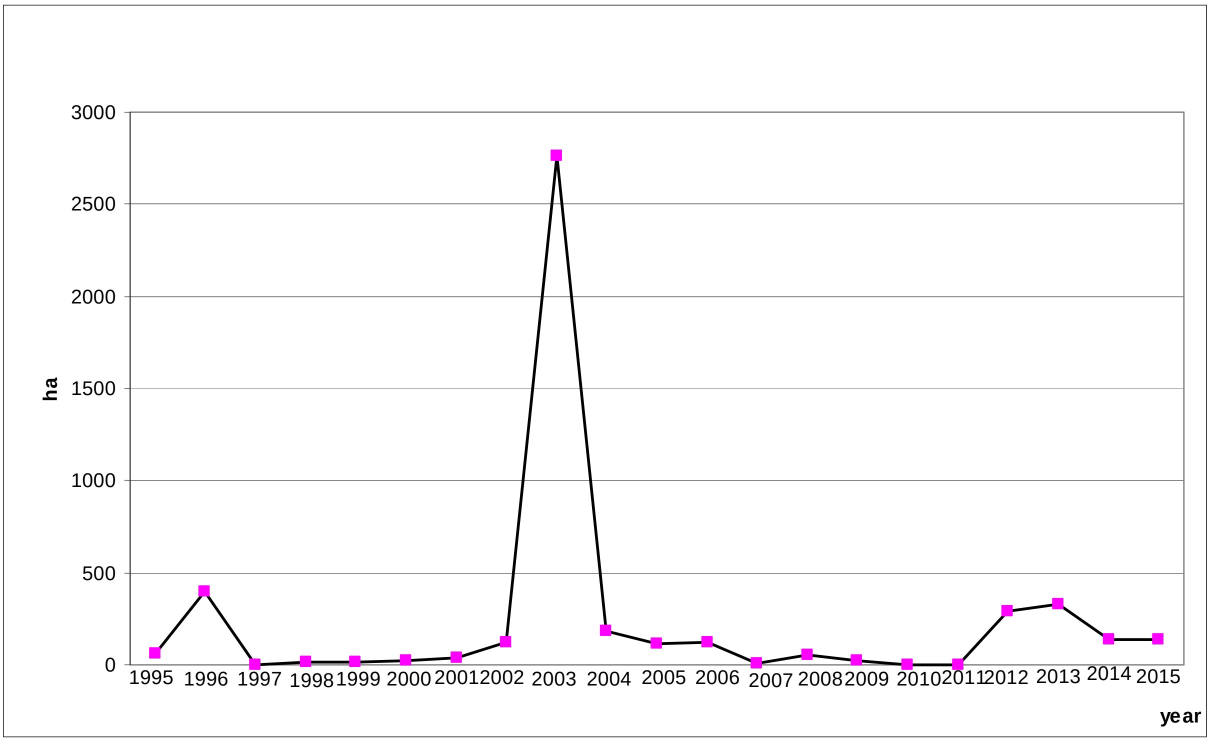

Figure 5: Surface area under attack of *Rhyacionia (Evetria) buoliana* in R. Macedonia in the period from 1995-2015

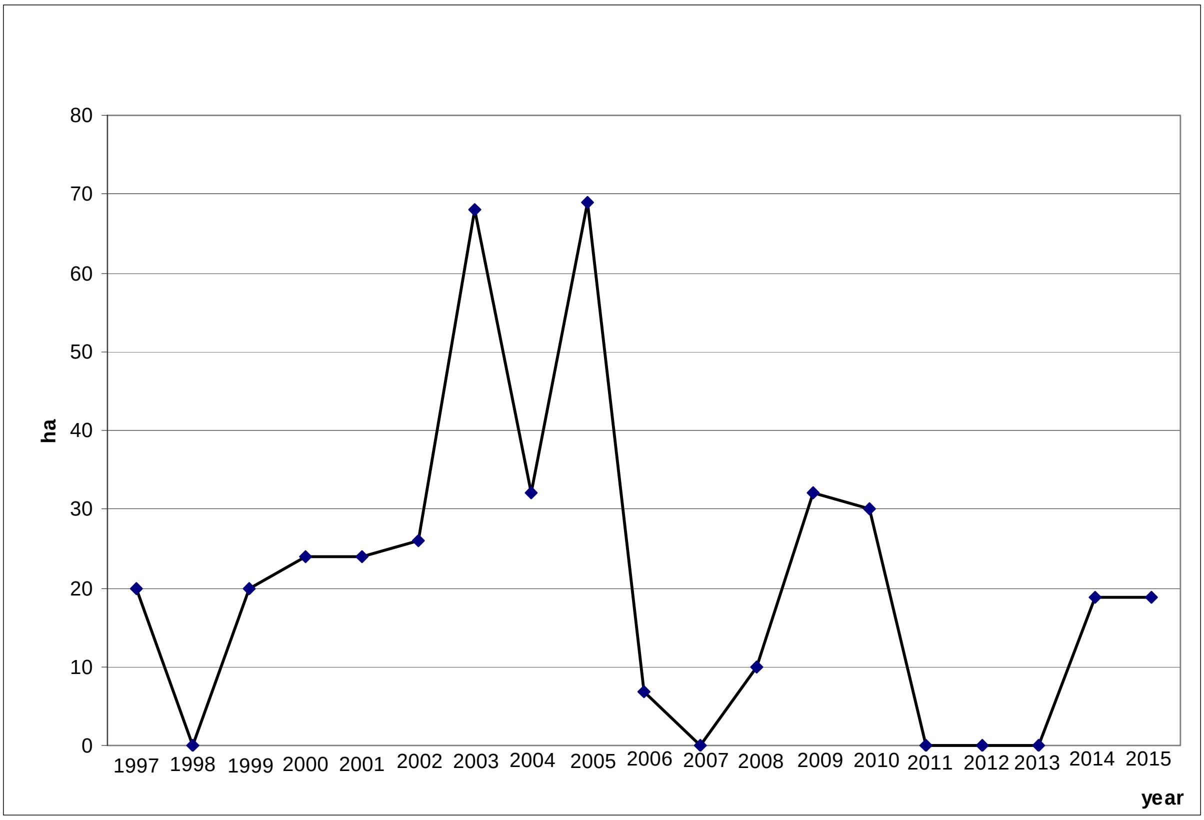

Figure 6: Surface area under attack of *Coleophora laricella* in the R. Macedonia in the period from 1997-2015

According to our field observations and registrations we can conclude that the larvae of this insect are present in almost all black pine cultures in the Republic of Macedonia, with populations which are currently in latency, so the hazard is very low on the most of attacked area. Intensity of attack by *N. sertifer* is medium on 54.7% of the total area or 420 hectares, and 37% or 287,5 ha low to medium, while the 7.8% or 60 ha are attacked with very low to low intensity. These data once again confirms the conclusion that this species is not a threat to

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the black pine stands in the year of 2016.

3.4 *Rhyacionia buoliana* Den. et Schiff.- Pine shoot moth

Pine shoot moth is one of the most important pests, with particulary distinct negative impact in the beginning period of the formation of pine ultures in R. Macedonia.

Low attack by *Rh. buoliana* is due primarily to the small number of newly afforested areas with black pine during the last ten years (Fig. 5).

3.5 *Coleophora laricella* Hb.- Larch casebearer

In the period of 1971-1985 on some localities in the regions near Bitola, Resen, Ohrid, Krushevo, Kochani and Skopje larch seedlings were introduced (*Larix europea*) wich were brought from the Republic of Slovenia. With this seedling larch casebeaerer was introduced in the R. Macedonia whose increasing abundance was observed in 1997 [2].

The aim of this study is to give information about the abundance and defoliations made by this invasive species in the larch stands in R. Macedonia.

Larch casebearer was not mentioned at all as a pest on larch in our country until 1997. We thought that our larch stands are sufficiently distant from the native areal of larch and we were expecting to appear much later.

During the year 1997 these insects were recorded on several localities in R. Macedonia (Kazani near Bitola, near Krusevo and also near Resen) in the small larch stands [2,13].

The intensity of the attack in this stands was estimated as strong (fig. 6). On the entire territory of R. Macedonia this species was represented on 20 ha. In the next three years (1998, 1999, 2000) larch caeseberer continued to cause defoliation with strong intensity in early spring almost everywhere where larch was present.

The largest area on which was observed is in 2005, when these species were present on 68,9 ha. In the latest years its presence is observed only on several localities near Kochani, Resen, Bitola and Krushevo in which the intensity of the attack is estimated as a medium (Fig. 6).

Abundance of the larch casebearer was 453,5 cases on loc. Pasadzikovo (near Kochani in 1997 to 805,4 in 1999 on the same locality.

4 CONCLUSIONS

Based on the field analysis and laboratory research we can give the following conclusions.

Th. pityocampa generation 2015/2016 was again a threat for the normal development of black pine stands on 13,000 ha in the Republic Macedonia.

Population density of the pine processionary moth, although with a trend of retrogradation in certain regions in 2015, is still high, ranging from 0.35 to 11.0 caterpillars nests by tree or from 700 caterpillars nests by 1ha, like in Kalaslari near Veles, to 22000 caterpillars nests by 1ha in Crnilishki rid –near Sveti Nikole.

Medium to high intensity of attack of pine processionary moth is observed in the following regions near: Kamenica, Vinica, Kocani, Stip, Radovis, Sveti Nikole, Negotino, Prilep, Bitola, Skopje, Kumanovo and Kriva Palanka, with serious threats for total defoliation in spring 2016.

For the total area of 13000 ha attacked by pine processionary moth aviosuppression was recommended for the September 2016

Not taking suppression measures may lead to deterioration not only of individual trees but also to deterioration of whole complex of black pine cultures.

From the pine bark beetles 3606.25 ha of pine forests were infested in 2015, and according to our knowledge area that is attacked is far greater.

Regions most affected by bark beetles in 2015 are: Kochani, Kamenica, Kriva Palanka, Kratovo, Bitola, Berovo, Pehcevo, Strumica and Prilep. Control measures are required to prevent their gradation in the spring 2016.

The other harmful insects registered in the conifer forests and cultures like *N. sertifer, Rh. buoliana, Pissodes notatus, Coleophora laricella*, are within normal range, their abundance is in latency and they are not threat for the normal development of these forest ecosystems.

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For. review 45: 24-29. Skopje, 2014
ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm
UDC: 334.722.012.63/.64:[334.724:630(497.7)"2010/2011"
Original scientific article

THE ROLE OF PUBLIC ENTERPRISE "MAKEDONSKI ŠUMI" IN DEVELOPMENT OF THE SMALL AND MEDIUM FOREST-HARVESTING SERVICES ENTERPRISES: THE CASE STUDIES OF TENDERS MADE IN 2010 AND 2011

[1]NIKOLOVSKI G., [2]STOJANOVSKA M.
[1]*Public enterprise for managing forests Makedonski sumi, Skopje, Macedonia*
[2]*Ss. Cyril and Methodius University in Skopje, Faculty of Forestry in Skopje, Skopje, Macedonia*
Corresponding author e-mail address: gonik@yahoo.com

ABSTRACT: Small and medium enterprises represent a very important segment of the national economy of developed countries. Republic of Macedonia is not an exception on this, where bigger number of the business entities comes under this category. The situation is reflected on the forestry sector as well, within which many SMEs offer their services to the Public Enterprise Macedonian Forests. The forest sector can secure work of the small and medium enterprises as: collecting, trading and processing of non-timber products, tourism and providing of recreational services, wood processing (sawmills); production of furniture and providing of services for performance of the forest harvesting services of cutting, hauling transport and transport of timber. The paper uses analysis of secondary data (both qualitative and quantitative data). The data are further rely on content analysis of the contract signed between Public Enterprise Macedonian Forests and small and medium enterprises for the period of 2010 and 2011. Thus, the main goal of this paper is analysing the number of contracts between SME`s and PEMF and the amount of money within that contracts in 2010 and 2011. The results have shown that 278 SMEs have signed 880 contracts with of around 1,7 billion denars for performing of forest harvesting and silviculture services. Taking into consideration the number of small and medium enterprises that provide services within the forestry area and according to the financial means allocated for their services, the provided analyses imply on good conditions for the small and medium enterprises work and their functioning in the country which has a good implication on the forestry and on the overall economy of the country, as well.
Keywords: forestry, forest services contracts, wood cutting, logging and transport of timber, PE "Makedonski šumi", forestry sector employees.

1 INTRODUCTION

Small and medium enterprises (SMEs) represent a very important segment of the national economy. They secure employment and offer services on the market, influencing the economy's growth. In Macedonia the SMEs has quite expanded in number due to the globalization and changing the system of the country. According to the State Statistical Office its number has reached around 99,75% of the business entities within the last two decades of the country's independence. [6]

This number counts the SMEs that provide forest-harvesting services, as well. Their field of acting decreases as a result of the forestry activities separation from the one of wood industry and fisheries. The Public Enterprise "Makedonski šumi" (PEMŠ), with governmental support, decided to decrease its activities making possibilities forest utilization services (cutting, hauling transport and transport of timber) to be conducted by private companies. The forest-harvesting SMEs, as positioned at the beginning of the forest sector network, assuring supply of technical and fire wood, which is necessary for functionality of the network. Forest harvesting SMEs are considered as essential actor of the forestry sector.

2 MATERIALS AND METHODS

The main goal of the paper is to identify the role of the PEMŠ in development of SMEs that provide forest-harvesting services. The analysis considers the contracts signed between the SME provide forest harvesting services and the PEMŠ. With aim to create comprehensive picture of the role of PEMŠ, it further looks at the forest harvesting services (cutting, hauling transport and transport of timber) identifying the total number of the SMEs, the contract values according to different stages (cutting, hauling transport and transport), and the total value of the contracts.

In this regards the paper uses analysis of secondary data, analysis of both qualitative and quantitative data (Neuman 2006, Bryman 2008, [7,8]). The main data collected are based on the content analysis of the contract signed between PEMŠ and SMEs for the period of 2010 and 2011. Additional data are collected from the archive of the PEMŠ administration office. According to the data availability (or access), various sources are used for these purposes, such as: contracts published online by the Public Procurement Office, Analysis of the work of the PEMŠ for 2010 and 2011, based on the data published on the internet sites of Central Register Office of RM, Statistical Office of RM. Additionally, consultation with representatives of the relevant policy actors has been done. This included consultants, Forest Faculty professors, PEMŠ top-level managers, all relevant for forest entrepreneurship issues in order to obtain comprehensive understanding of the status and situation of SMEs that provide forest-harvesting services.

3 RESULTS

3.1 Public enterprise "Macedonian forests" (PEMŠ)

On December 15th 1997, the Government of Republic of Macedonia (RM) brings a decision for establishing the PEMŠ. It will officially start with the working activities on January 7th 1998 as a legal successor of several forestry units until than independently managing the state forests. [7]

The PEMŠ will inherit the forest management of state forests as a main business activity, ending up with of 840.897 ha [2], or 93, 78% of the state forests in RM today.

Until the year 2000, the PEMŠ was responsible for conducting the harvesting activities (cutting, hauling transport and transport of timber) in state forests. In 2000 the PEMŠ in coordination with the Government of RM decides to privatize these activities. These PEMŠ decisions contribute for establishing large number of SMEs offering forest-harvesting services on the market in RM. As results of this each year PEMŠ signed large number of contracts for realization of forest harvesting services for cutting, hauling transport and transport of timber with SMEs register for forest harvesting activities.

3.2 Public procurement contracts

The changes in the Law for public procurement [9] the PEMŠ is obliged all contracts for doing harvesting services to be done with engagement of private companies through public listings. According to the data from the PEMŠ administration office, 200 SME signed contracts for doing harvesting operations, every year. The data show that these SMEs are mainly micro (family) businesses with small number of employees. The paper analyses 855 public procurement contracts signed during the period of 2010 and 2011. These contracts are published on the official web page of the Public Procurement Office within the frameworks of the Ministry of Finance of Macedonia.

Analysis of the Public procurement Listings/calls. Every year, PEMŠ announces public procurement calls for tenders on execution of various forestry services and continuous execution of the production process. Based on these listings of public procurement and related to the performance of forestry services, PEMŠ has engaged large number of forest private harvesting companies. These listings present all physical and legal persons who fulfill the conditions stipulated in the public announcement. They submit their offers to the PEMŠ which later chooses the most favourable offer and signed an contract with this physical or legal person for one year or until they complete their contractual obligations.

In 2010 and 2011, PEMŠ have signed contracts for cutting, hauling and transport on the basis of six announcements for public procurement. Based on these six public procurement announcements, PEMŠ have signed a 855 contracts out of which 576 contracts have been signed in 2010 and 279 contracts in 2011.

In Table I present the amount of signed contracts by announcements over the past two-year and their estimated and realized value.

Table I: Chronology of Public listings according to signing the contracts

Year	Date of publishing the Procurament	Total signed Contracts	% of all Contracts	The Value of procurament with VAT	Value of the signed Contracts with VAT	% of estimated value
1	2	3	4	5	6	7
2010	11/17/2009	389	67.5	702,356,324.00	583,638,392.00	83.1
	5/10/2010	166	28.8	239,077,877.00	181,299,495.00	75.8
	7/20/2010	21	3.6	97,206,276.00	83,175,694.00	85.6
Total		**576**	**100.0**	**1,038,640,477.00**	**848,113,581.00**	**81.7**
2011	11/18/2010	188	67.4	802,430,049.00	568,730,042.00	70.9
	4/4/2011	89	31.9	289,699,979.00	199,323,146.00	68.8
	9/1/2011	2	0.7	9,281,880.00	7,598,482.00	81.9
Total		**279**	**100.0**	**1,101,411,908.00**	**775,651,670.00**	**70.4**

The results shows that most of the contracts for 2010 were signed with the public procurement announcement from November 2009, with this call 389 contracts have been signed although they were valued at 702,356,324.00 denars, bids reached a value of 583,638,392.00 denars, which was 83.1% of the estimated value.

On 10.05.2010 was published another public procurement announcement for new contracts. These contracts were signed within the period of the following four months, starting from 21.07.2010 when the first contract has been signed in this announcement, until 23.11.2010 with signing the last one. This announcement has been valued at 239,077,877.00 denars and 166 contracts have been signed with value of 181,299,495.00 denars, which represented 75.8% of the appraised value.

The practice for each stage of signing a separate agreement creates additional extra activities for the PEMŠ administration. The submission of big in number necessary documents creates additional difficulties for administration office, contributing the entire procedure to be more complex, more expensive and slower. This in conditions of work in the forest with seasonal character can negatively reflect on the production volume.

Recognizing these issues, the public procurement announcement published on 20.07.2010 made a simplification of the procedure for application of signing only one contract with each company for performing services of several phases instead of signing contract for each working phase separately with one company. This reduction of the total amount of contracts resulted in saving time and money of both contractual parties. The simplification of procedure has resulted with signing only 21 contracts, based on the announcement 07-1528 / 2/2010, where most of which were for performing services for more than two phases. These contracts needed relatively short period to be signed in, where from 06.09.2010 until 12.10.2010. Although they were valued at 97,206,276.00 denars, they reached a value of 83,175,694.00 denars, which was 85.6% of the appraised value. Anyway, this way of signing has been assessed as a very practical, so the majority of the contracts signed on the basis of all subsequent notices were to perform services for more than two stages of the forest management process.

With the announcement from November 2010 188 contract have been signed. This represented 67.4% of all contracts for the conducting forest-harvesting services for the phases of cutting, hauling transport and transport of wood assortments, which is almost identical percentage as in the previous year. The total value of this announcement has reached agreements worth 568,730,042.00 denars, which was only 70.9% of the estimated value of 802,430,049.00 denars. Signing of these contracts took a relatively longer period, where from 25.03 until 18.10.2011, when the last contract was signed.

In 2011, the first announcement for public procurement was published on 04.04.2011, registered under the number of 07528/2/2011. This announcement has been estimated on 289,699,979.26 denars. However, the total value of the 89 contracts signed under this announcement reached a value of 199,323,146.00 denars, which was 68.8% of the estimated value.

In September 2011 additional announcement was published, registered under the number of 07-1121/2/2011. With this announcement 2 contracts have been signed. They have been valued at 9,281,880.00, denars, but have reached a value of 7,598,482.00 denars, or 81.9% of the estimated value. The Fig. 1 below gives clear picture that as a result of the lower value of the offers, the signed value for the contracts in both years was less than estimated. The value of contracts signed in 2010 amounted to 848,113,581.00 denars, which was

81.7% of their estimated value in that year amounted to 1,038,640,477.00 denars. In 2011 the difference between realized and estimated value of the contracts was even greater because of the estimated total 1,101,411,908.00 denars they reached a value of 775,651,670.00 denars, which was 70.4% of their estimated value.

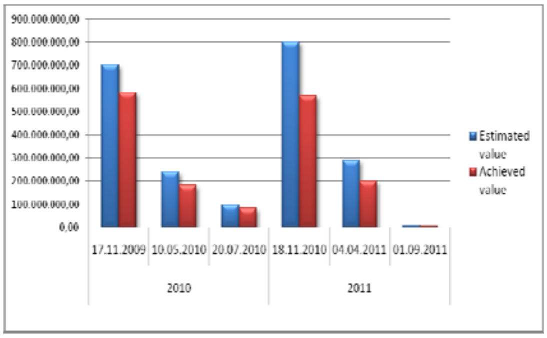

Figure 1: Estimated and realized values of the public listings

Structure and value of the contracts. Simplifying the procedure for contracts has led in 2011 to be sign 51.6% less contracts compared to 2010, although the value of the contracts was reduced for 8.5%. The following Table II gives a tabular representation of the number of signed contracts and their total value at the stages of the manufacturing process.

Table II: Number, structure and total contract values

Phase	2010				2011			
	No of Contracts	%	Contracts values (in denars)	%	No of Contracts	%	Contract values (in denars)	%
1	2	3	4	5	6	7	8	9
Cutting	185	32.1	217,583,526.00	25.7	13	4.7	18,301,906.00	2.4
Hauling transport	201	34.9	250,478,996.00	29.5	26	9.3	36,142,565.00	4.7
Transport	177	30.7	309,978,607.00	36.5	71	25.4	152,434,359.00	19.7
Cutting / Hauling	3	0.5	12,187,346.00	1.4	70	25.1	160,673,231.00	20.7
Cutting / Transport	1	0.2	1,773,139.00	0.2	7	2.5	38,075,504.00	4.9
Hauling / Transport	3	0.5	5,450,024.00	0.6	9	3.2	27,576,831.00	3.6
Cut. / Haul. / Transp.	6	1.0	50,661,943.00	6.0	83	29.7	342,447,274.00	44.1
Total	**576**		**848,113,581.00**		**279**		**775,651,670.00**	

The Table II shows that in 2010 only 563 contracts has been signed to perform only one stage services while for performing more than two stages services only 13 contracts were signed. Out of the contracts signed in this year, 201 contracts were for hauling transport phase, or 34.9% of all contracts, 185 contracts were for cutting phase and 177 contracts were for signed for obtaining transport services.

As compared to the previous year, typical for the contracts signed in 2011 is that out of 201 made contracts; only 13 were signed for performance of the cutting phase. 83 contracts, or 29.7% of the total were signed for performance of all three phases, while only 7 contracts or 2.5% of the total were signed for performance of the phases of tree cutting and transport (Figure 3).

Analysing the value of the contracts by phases in 2011, the contracts made for all three phases have the highest value. The SMEs that have signed these contracts gain 44.1% more, compared to the total value of all contracts signed in 2011. Oppositely the SMEs that applied only for cutting phase, gain the lowest value or only 2.4% of the total value of all contracts.

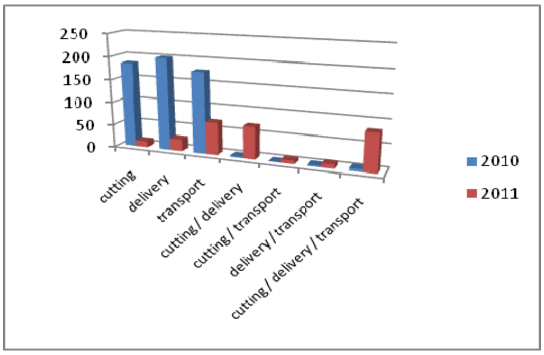

Figure 2: Number of signed contract according to phases

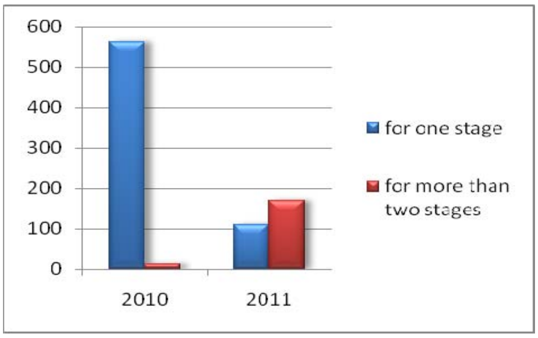

Figure 3: Contract ratio according to number of phases

Number of SMEs providing forest harvesting services. Every year PEMŠ signs contracts with SMEs to carry out forest harvesting services. With some of these companies it signs more than two contracts, which is the reason why the number of signed contracts is greater with respect to the number of SMEs that have been engaged for performing the needed services. In 2010 PEMŠ has engaged 213 SMEs, where the total number of contracts signed was 576. While in 2011 PFMŠ has engaged 194 SMEs with which has signed 279 contracts. If we take the year 2011 with comparison to 2010 the number of SMEs that have signed contracts with PEMŠ for forest harvesting services in phases has decreased by 8.45%, which corresponds identically to the percentage of reduced value of the contracts signed in 2011.

Table III presents the contracts number of enterprises in year 2010 and 2011 which have been engaged by the PEMŠ for carrying out forest harvesting services, with the value of contracts the companies signed per forest harvesting phase.

The Table III below shows that the companies with contracts signed for doing all three phases were the most in number. This is presented and visually with the Fig. 4, below. In 2010, PEMŠ have signed 78 such three phases performing contracts or 36.6% of the total number of contracts. In 2011 the number of contracts signed for performance of all three phases has increased to 84, at the same time increasing the percentage up to 43.3% of the total contracts signed in 2011.

Fig. 5 shows that in 2010 and 2011 the contracts signed for three phases not only that were the most numerous, but they were the most worthy contracts as well. The value of these contracts has reached 489,061,340.00 denars in 2010, which was 57.7% of the

For. review 45: 24-29. Skopje, 2014
Ss. Cyril and Methodius University in Skopje
Faculty of Forestry in Skopje ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm

total value of all contracts for that year, unlike in 2011 when their value dropped to 415,044,378.00 denars, as 53.5% of the value of all contracts of the same year.

Table III: Number of SMEs according to phases and contract values

Phase	2010				2011			
	No of SMEs according to phases	%	Contract values according to phases (in denars)	%	No of SMEs according to phases	%	Contract values according to phases (in denars)	%
1	2	3	4	5	6	7	8	9
Cutting	11	5.2	22,222,188.00	2.6	8	4.1	15,512,327.00	2.0
Hauling transport	18	8.5	34,320,200.00	4.0	12	6.2	22,104,175.00	2.8
Transport	40	18.8	73,851,798.00	8.7	37	19.1	116,112,457.00	15.0
Cutting / Hauling	47	22.1	162,775,245.00	19.2	41	21.1	139,358,024.00	18.0
Cutting / Transport	10	4.7	35,814,656.00	4.2	7	3.6	40,862,564.00	5.3
Hauling / Transport	9	4.2	30,068,154.00	3.5	5	2.6	26,657,745.00	3.4
Cut. / Haul. / Transp.	78	36.6	489,061,340.00	57.7	84	43.3	415,044,378.00	53.5
Total	**213**		**848,113,581.00**		**194**		**775,651,670.00**	

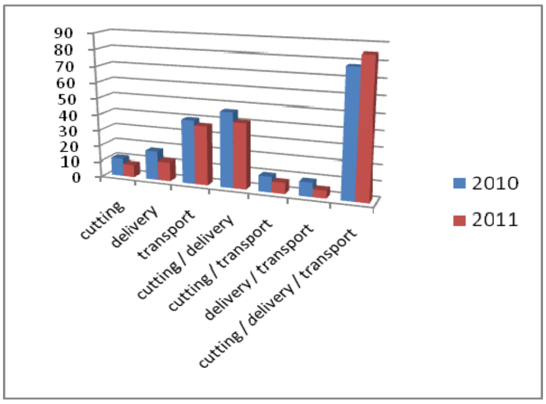

Figure 4: No of SMEs according to phases

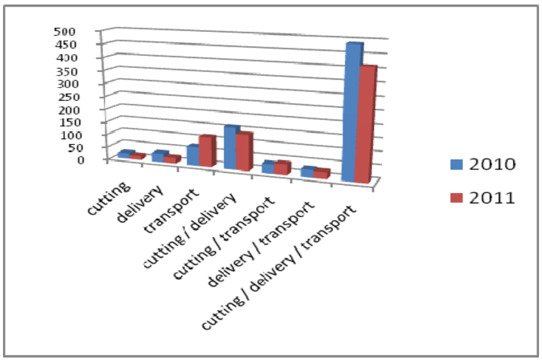

Figure 5: Contract value according to phases (in million denars)

However, despite the fact that the contracts signed for the hauling transport phase appeared in the smallest number, the contracts signed only for the phase of cutting appeared to have the lowest value. Their contracts in 2010 had a total value of 22,222,188.00 denars or 2.6% of the value of all contracts, while in 2011 only 15,512,327.00 denars, which was only 2.0% of the total value of all contracts in the same year (Fig. 4).

Comparing the SMEs, based on the contracts signed for different number of phases, it can be noticed that the number of SMEs that performed services in all three phases, has increased in 2011 at the expense of the companies that perform services of one or two phases. Thus, the percentage of forest harvesting SMEs that perform forest harvesting services for all three phases of 36.6% in 2010 increased to 43.3% in 2011, while the percentage of companies that carry out forest harvesting services and one of two phases has been reduced from 32.4% to 29.4%, from 31.0% in 2010 to 27.3% in 2011.

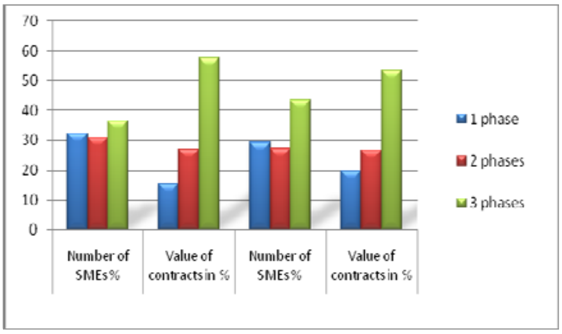

Figure 6: Ratio between SME and the contract value according to the phases

Fig. 6 presents the percentage ratio between forest harvesting SMEs that perform one, two or three phases, and the percentage difference in the value of their contracts.

Many of the SMEs have signed contracts for performing services of different phases. In 2010 67.6% of forest harvesting SMEs and 70.6% in 2011 signed contracts for performing services of several phases. Table IV presents that the number of forest harvesting SMEs that have signed contracts for the phases of cutting, hauling and transport, as well as the total number of contracts that individually or in combination with another phase was included in any of the phases.

Table IV: No of SMEs that have signed contracts for any of the three phases

Phases	2010				2011			
	Total Contract	%	Total SMEs	%	Total Contract	%	Total SMEs	%
1	2	3	4	5	6	7	8	9
Cutting	195	33.9	146	68.5	173	62.0	140	72.2
Hauling	213	37.0	152	71.4	188	67.4	142	73.2
Transport	187	32.5	137	64.3	170	60.9	133	68.6

In Table IV, the most in number forest harvesting SMEs for both years have concluded contracts that included only the phase hauling individually or in combination with other phases. In 2010, 152 forest harvesting SMEs, or 71.4% of SMEs with contract including the phase hauling individually or together with another phase, have signed 213 contracts. For all three phases 78 forest harvesting SMEs have signed a contract for carrying out services, 47 forest harvesting SMEs have signed a contract for carrying out the cutting phase, 18 have signed a contract for hauling phase and 9 forest harvesting SMEs have signed a contract for transport phase (Table IV).

For performance of cutting phase 146 forest harvesting SMEs or 68.5% of the total SMEs have concluded contracts, while PEMŠ have concluded contracts with 137 forest harvesting SMEs for carrying out services for the transport phase or in percentage even 64.3% of the total SMEs with whom PEMŠ in 2010 have signed contract for performing forest harvesting services.

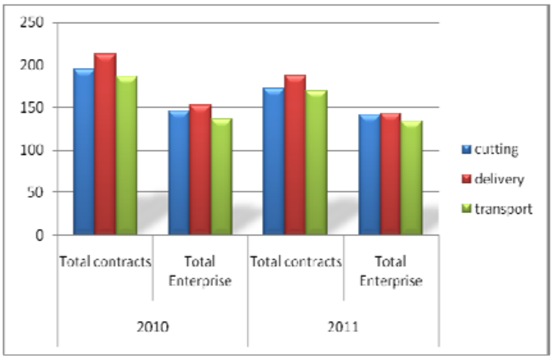

Figure 7: Total SME versus contracts signed according to phases

The ratio was similar in 2011. As in the previous year, large number of forest harvesting SMEs has signed contracts that included hauling phase separately or combined with other phases. 142 forest harvesting SMEs signed such agreements. Although this number decreased by 10 companies in 2011, at the same time the percentage of companies that perform services in this stage have increased from 71.4% to 73.2%. In other words, the number of enterprises with the signed contracts for performance of forestry services of phase hauling has been increasing compared to the other forestry services of production process stages.

In 2011, 140 SMEs have concluded contracts to perform services for the cutting phase. This represents 72.2% of the total number of enterprises, or compared to the previous year 6 companies less than the previous year.

The transport phase, as of the previous phases, has reduced in the number forest harvesting SMEs. So in 2011 133 SMEs, or 68.6% of the total SMEs, have signed agreements on service performance in this phase, which is 4 enterprises less compared to the previous year.

4 DISCUSSION AND CONCLUSION

The data elaboration of this paper shows that the small and medium forest enterprises in Macedonia can perform work not much elsewhere available and in that way affect alleviation of the poverty, in the country. The fact that more than 90% of the wood production of the PE “Makedonski šumi” is done by these enterprises, confirms that the SMEs improve the livelihood and secure support in that way. Taking into account the significant number of SMEs on the market, the number of contracts that were signed during 2010 and 2011 and the amount of money spent on these contracts, the main conclusion drawn can be that there are optimal conditions for the SMEs existence.

The problems that PE “Makedonski šumi” faces with, in connection to the contracts realisation with SMEs, have direct influence on the Public enterprise’s production plan realisation. For this purpose, the PE “Makedonski šumi” should work on strengthening its cooperation with the SMEs that offer services in the forestry area, in order to facilitate their work and to help them to cope more easily with the problems related to performance of their work.

According to the number of small and medium enterprises that provide services within the forestry area and according to the financial means allocated for their services, the provided analyses imply on good conditions existing for the small and medium enterprises work and their functioning in the country.

Taking into consideration the many positive features of the small and medium enterprises as well as of the entrepreneurship in general, it can be expected that the functioning of the small and medium enterprises on a longer time period can provide positive implications on the forestry in general and on the overall economy of the country, as well.

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For. review 45: 30-36. Skopje, 2014
ISSN 1857-9507 on-line: www.sf.ukim.edu.mk/sumarski_pregled.htm
UDC: 712.252(497.711)
Professional article

THE GREENERY OF FOUR MOST IMPORTANT BOULEVARDS IN SKOPJE

[1]RIZOVSKA ATANASOVSKA J., [2]VULGARAKIS V.
[1]*Ss. Cyril and Methodius University in Skopje, Faculty of Forestry in Skopje, Skopje, Macedonia*
[2]*Public enterprise Parks and greenery-Skopje, Skopje, Macedonia*
Corresponding author e-mail address: jratanasovska@sf.ukim.edu.mk

ABSTRACT: The boulevard greenery in Skopje, besides the other greenery in the city should fulfill particular functions for an urban environment. The most important one is to be a purifier of the polluted air close to the roads or boulevards. Besides that, it has to be decorative, contributing to the aesthetic image of the city. The most important for functioning of this type of greenery in this climate conditions, is: the proper irrigation system, the place of growth, the influence of the conditions of the environment and the human factor. It aims to be effective and functional, in accordance with the current conditions on the location, as well as using proper measures for its maintenance.
Keywords: boulevard greenery, urban environment, aesthetic image, City of Skopje.

1 INTRODUCTION

The greenery in an urban environment has positive influences on many aspects of people's life. In first place it influence in seizing the air pollution and high summer temperatures but there are other benefits too, considering the life in a big city with a lot of traffic and industry..Boulevards could be understood as open systems that have multiple functions and provide: safety to the traffic, open green spaces, usage of the boulevards for cycling and pedestrians, sustaining the life of the city streets and prevention of traffic jam. Through the years, boulevards were changing according urban planning of the cities.

Boulevards date from XVI century when medieval towns left their fortresses and transformed them into wide tree pathways. The cities of Amsterdam and Strasbourg were among the first that developed in that direction. In 1670 the walls around Paris were taken down and replaced with promenade streets used only by aristocrats. The boulevards then became important and were also widely used for different aims. There were attempts for creating system of boulevards as they are in Brooklyn, called avenues. They were meant to be for suburbs as opposition to the traditional ones, but still they have the characteristics of the boulevards. They could be:

- main inner city streets,
- commercial arteries of the suburbs,
- existing highways that pass through the city,
- wide arteries of the suburbs planted with trees and flowers,
- main traffic streets.

At the beginning of the XX century in Skopje, were raised up avenues and lawns and especially important, a green area that through the years become bigger, on location where today's City Park is built. Nowadays, it is spread out and enriched with many elements. As the city extends the need for parks and green areas grows more. So, there were built up many of them after the II World War and especially after the catastrophic earthquake in Skopje in 1963. In that time with the urban planning there were built many parks and different kinds of green areas. But after that planned planting period (the renewal of the city), there was a period when they were raised more spontaneously. The reasons for that were diverse.

In Skopje today we have various attitudes considering the greenery. Mostly, in the parts of the city where new settlements are situated, there are raised up parks and other types of green areas. Among them the boulevard greenery is taking a great part. Some very important streets were renewed, the old trees were replaced with new ones, and new vegetation was planted too.

This type of greenery is present in the bigger avenues in a different way, more functional and decorative as it was before, considering the conditions as very specific: pollution inconvenient conditions relating their ecology and dimensions.

There are four boulevards in Skopje that can be considered as most frequent ones. They are built up with plants situated in jardinières in split bars in the middle of the roads and the ones in the greenery on the sidewalk.

2 MATERIAL AND METHOD

The subject of research of this article is boulevard greenery on four boulevards of the wider central area. These boulevards are: „Ilinden“ Aleksandar Makedonski“. „Partizanski Odredi“ and „Jane Sandanski“. They are most frequent and can be considered as the most important city arteries.

The aim of investigation relates with the behavior of this kind of greenery in the specific conditions in a way they fulfill the basic aim they are planted for, or are they functional and decorative in both ways considering the main aspects for their planting, which is mostly in a role of improving the urban environment.

The method of work is based on theoretical-conceptual, practical and research approach which means that the analysis includes research realized in phases:

In first phase proper literature and concrete projects had to be gathered.

Second phase means that there were analyzed the ecological conditions of the locations, like climate and hydrology considering there anthropogenic factor too.

The third phase consists of field research analysis and recognition of condition of the boulevard greenery from many aspects: functionality, efficiency and taxa composition considering the characteristics of the locations. During the process of research it was prepared photo documentation, which was later used in the phase of analyses and processing of the gathered information.

The fourth phase is office work analyzing the information and data over the following elements:

- prevalence of the greenery in the boulevards,
- determination and analysis of the plant species in the researched location,
- existence of the specific floral compositions (figures) that are part of the boulevard greenery,

- analysis of the functionality of the boulevard greenery,
- analysis on condition of the adaptive plant species according location conditions.
- These researches further give answers on many questions connected to the main aims of the article and give realistic view on this type of urban greenery which further leaded to concrete conclusions.

3 THE ROLE OF THE BOULEVARD GREENING FOR THE URBAN ENVIRONMNET

Boulevards can be new streets, main streets, existing boulevards adjusted after long period of neglecting [1]. The boulevards are functioning as big arterial streets or small commercial roads. They have social component as well as transit function depending on the activities. They are axis of a bigger street net so they should be on locations that can enable improvement of the existing system of the streets. When building the boulevards it should be ensured all the components for its functionality.

Considering today's way of living, we are facing a fact of devastation of the natural landscapes. Green areas are used more and more for the needs of the community for: commercial, industrial or recreate purposes. In an urban environment beside the other elements there are plants as natural elements that can appear in various forms and in different types of greenery. Planting trees, shrubs or flowers in order of editing the boulevards greenery is according a plan of which they should be set on proper locations considering their age, height, morphological specifics and characteristics of the location, resistant on the conditions of the habitat, or on changes as a result of the negative affection of the anthropogenic factor. Examples for that are trample of the soil, exposure on harmful substances, among others, the damage that salt is making in winter days in the zone of the root system.

The plants used in this kind of greening should have these characteristics: to be resistant on air pollution, to stand the specific conditions of the habitats and to be decorative in the same time. So, there should be used species with decorative flowers, leaves or habitus, but avoid fruitful species, for they can mess up the space on the ground. In Skopje, in the older boulevards there are *Platanus acerifolia* (Aiton) Willd, *Platanus orientalis* L., *Tilia tomentosa* Moench, *Tilia cordata* Mill. *Fraxinus americana* L., *Fraxinus angustifolia* Vahl., *Acer pseudoplatanus* L., *Acer platanoides* L., *Aesculus hippocastanum* L., *Catalpa bignonioides* Walter.

Through the ages, there appears some kind of weaknesses on the greenery. They are exposed on diseases and calamities, especially avenue trees because they are built up of one kind of specie in a line or simply because they are affected of urbanization. It often happened in urban areas with bigger air pollution and restriction on conditions of their habitats, that directly affects the physiognomy of the plants, the condition of their habitus, trunk or root. In some cases authorities approve that the price for common maintenance of the avenues is much bigger in spite the pollution for a longer period of time. It is recommended to grow up species with endurance on dry conditions that further means financial savings considering irrigation expenses. Projects made nowadays follow the needs of a concrete urban environment.

Every urban area has its own specifics which can make changes in the life conditions of the plants. The concentration of smoke, dust, toxically gases and mechanical substances there are very big and can influence on physiological processes of the plants such as photosynthesis and transpiration which means that the harmful substances damage the chlorophyll and the leaves. Over the wider central area of Skopje very often there are thick layers of fog and smog where big amounts of CO_2 and other toxic substances, in condition of aerosols, are concentrating. The smoke consists of many harmful substances among them acids in gas condition. They are much more dangerous if they appear together with fog and water, so leaves of the trees susceptible on smoke dry up and fall earlier. Later the branches start to dry up and the whole plant wither.

The soil quality can change with a continuous mechanical pressure over which it becomes more compressed without much air in it and the plants have difficulties in using the air from the soil, or they just couldn't use it at all during their growth.

Maybe the biggest influence of the anthropogenic factor on the city greenery is polluted water. Especially dangerous are detergents and pesticides. Trees that grow near the water flows, together with water take harmful substances. But the biggest damage is done by humans. They make:

- bark and trunk damage (engraved signs and letters on trees near the paths, streets, parking zones),
- damage on roots (by building objects, paths),
- damage with various objects and installations.

4 RESULTS AND DISCUSSION

Boulevard greenery is very important segment of any urban environment. It is raised up near boulevards, streets, pedestrian or bicycle paths, in the split bars of the roads in forms of trees, shrubs, or various flower compositions. We can say that boulevards are wide city streets, with monumental architecture used by everyone that takes part in the traffic. They are often "monumental connections between the different destinations [1].

In some countries the term "boulevard" is replaced with the term "avenue" The boulevards are characteristic of the big cities and metropolises and each of them have its own style and aesthetic according the standards of the city and its urban planning. Greenery there gives the boulevards decorative and ecological dimension. It could be realized over the projects from the city authorities. It must be framed in the street open space. It depends on: location, type of the soil, microclimate conditions of the area, anthropogenic factor when choosing the kind of species (trees, shrubs and flowers) for planting.. Speaking of anthropogenic influence, in some parts of the city (Skopje) the sidewalks near the streets are occupied with parked cars so the pedestrians must go over the nearby lawn. In that case there should be planted small groups of plants chosen not to block the view to the drivers. Usually there are set groundcovers.

City greenery consists of few categories green areas and the boulevard greenery belongs to the category of public greenery. In Skopje, at the beginning of the XX century there were green areas, avenues with trees and lawns. In that time, a park area was raised up on the location where today's "first part" of Skopje City Park is situated. Small part of that area exists even now. After the World War II and especially after the 1963 catastrophic earthquake together with the renewal of the city, there were built up more green areas from various categories such as squares and small parks. In that time the City Park was reconstructed and rebuilt on wider area which permanently, through the years spread out in today's borders.

In Skopje continually were built up various types of green areas which in general brought benefits to the citizens. But they were not always in good condition. The standards for green areas in Skopje per capita according its urban planning is 14-15 m^2. The total area of green spaces in the city as public greenery is 1 302 457 m^2 and is shown in Table I according JP Parkovi i zelenilo (Public Enterprise "Parks and greenery").

Table I: Overview on the green areas in Skopje

	Green areas in Skopje	
	Park areas	**m^2**
1	City Park, I and "Opatia"	904,223
2	City Park II	98,910
3	Park "Zena - Borec"	290,385
4	Boulevard greenery	8,939
	Sum	**1,302,457**
	Block green/Municipality	**m^2**
1	Centar	195,484
2	Karpos	610,063
3	Gorce Petrov	87,735
4	Kisela Voda	196,327
5	Aerodrom	804,519
6	Gazi Baba	192,151
7	Cair	297,700
8	Butel	74,946
9	Suto Orizari	1,300
	Sum	**2,460,225**
	Suburban greenery	**ha**
1	Park forest Vodno (summary)	4,537
2	Park forest Vodno (under wood)	2,168
3	Bare land ground and degraded areas	1,555
4	Agriculture rural area (objects, yards)	850
5	Park-forest „Gazi Baba"	105
6	„Francuski grobista"	7
7	„Zajcev Rid"	5
	Sum	**9,227**
	Sport-recreate centers	**m^2**
1	Treska Lake	185,678
2	Saraj	240,000
	Sum	**425,678**

The Table I shows that from the whole sum of green areas 1,302,457 m^2,on boulevard greenery is 8,939 m^2, the suburban greenery is 9 227 m^2 and sport-recreate centers have 425 678 m^2 greenery.

The boulevard greenery in an urban environment recognizes the basic criteria for using the vegetation in function of putting an ecological dimension, providing that way proper balance in complex urban system. That influences the efficiency of the greenery.

According to relevant data from "Local Action Plan for Environment of The City of Skopje", LEAP 2) the need for planned renewal and reconstruction of the greenery is highlighted "with purpose of preserving and improvement of the quality of an urban environment through various solutions" [2].

The research for this article was made on the biggest, most frequent boulevards with a lot of traffic and greenery: "Partizanski Odredi", "Ilinden", "Jane Sandanski" and "Aleksandar Makedonski". These boulevards were recently reconstructed; especially boulevard "Ilinden", where the old trees were cut and replaced with new ones. Similar happened to the other boulevards; they were reconstructed with various kinds of plants, especially their jardinières.in the split bars on the roads. There were planted shrubs and trees (with bigger and smaller dimensions) and flower figures in various forms: butterfly, turtle, swan, stork and snail in different locations along the boulevards. They are made of wire constructions filled with turf in which flower compositions were set. They are made of: *Aurinia saxatilis* (L.) Desv., *Begonia cucullata* var. *hookeri* (A.DC.) L.B.Sm. & B.G.Schub., *Brassica oleracea* L.-wild cabbage, *Viola tricolor* L., *Verbena hybrida* Groenl. & Rumpler, *Tagetes erecta* L., *Impatiens walleriana* Hook.f., *Ageratum houstonianum* Mill. *Myosotis sylvatica* Hoffm., *Plectranthus scutellarioides* (L.) R. Br., *Petunia hybrida* Vilm. They are being replaced by seasons after the blossom fade away.

For irrigation of this flower figures it is used „drip ieregation" system. Decision for their location bring up city authorities. For their maintenance cares PE „Parkovi i zelenilo".

In past decade public enterprise "Parkovi i zelenilo" under the city authorities, were working in phases on improvement on the conditions of the locations for setting up new plants by putting new layers of qualitative, fertile soil and setting irrigation systems.

4.1 The "Ilinden" Boulevard

In 2010 the Ilinden boulevard was reconstructed in a way that it was widen up with new traffic lines and enriched with proper greenery especially in the split bar. The underground installation of irrigation systems was destroyed by the work on various objects. So the vegetation there had to be irrigated by water tanks. Later, when the hydrant net was rebuilt there was installed equipment even for manual watering.

With the rebuilt of the boulevard, the greenery was enriched with flower compositions, shrubs and trees. There were planted very specific exotic trees with decorative morphological characteristics.

Starting with the crossing of the boulevards "St Kliment Ohridski" and "Ilinden" along to the City Park were planted 66 plants. The part of the boulevard where it cross the boulevard 8th September" was planted with 78 trees The jardinière in the middle of the boulevard was widen, 2.5-5 m and has about 2000 m^2. At the sidewalk near to the boulevard were planted 120 plants, most of them *Malus floribunda Van Houtte.* Along the boulevard,

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near the Zoo there is parking place where *Prunus serrulata Lindl*.was planted. There was built up lawn and flower compositions on it too. The whole area was set with drip irrigation system.

Figure 1: Floral sculpture at "Ilinden" Boulevard

Figure 1 presents a floral sculpture "turtle" made of wire construction where considering the seasons are set different kinds of species. Here are *V. tricolor* and *B. oleracea - wild cabbage .*

The greenery of "Ilinden" Boulevard will be presented here.

Plant species at "Ilinden" Boulevar:

- *Cedrus atlantica* (Endl.) Manetti ex Carrière
- *Chamaecyparis lawsoniana* (A.Murray bis) Parl.
- *Picea pungens* Engelm.
- *Thuja occidentalis* L.
- *Thuja orientalis* L.
- *Juniperus horizontalis* Moench.
- *pseudoplatanus*
- *bignonioides*
- *Fraxinus ornus* L.
- *Malus floribunda* Siebold ex Van Houtte
- *Cedrus deodara* (Roxb). C.Don f.*"pendula*
- *P. orientalis*
- *Prunus serrulata* Lindl.
- *Robinia pseudoacacia* L.
- *T. tomentosa*
- *Cotoneaster horizontalis* Decne
- *Euonymus alatus* (Thunb.) Siebold
- *Forsythia suspensa* (Thunb.) Vahl.
- *Photinia x fraseri* Dress.
- *Mahonia aquifolium* (Pursh) Nutt.
- *Prunus laurocerassus* L.
- *Pyracantha coccinea* M. Roem
- *Rosa rubiginosa* L.
- *Ageratum houstonianum* Mill.
- *Aurinia saxatilis* (L.) Desv.
- *Begonia cucullata* var. *hookeri* (A.DC.) L.B.Sm. & B.G.Schub.
- *Brassica oleracea* L. *Wild cabbage "Osaka"*
- *Celosia argentea* L.var. *cristata* L.
- *Chrysanthemum morifolium* Ramat.
- *Dianthus chinensis* L
- *Impatiens walleriana* Hook.f.
- *Myosotis sylvatica* Hoffm.
- *Petunia hybrida* Vilm.
- *Tagetes erecta* L.
- *Verbena hybrida* Groenl. & Rumpler.
- *Viola tricolor* L.
- *Vinca major* L.

4.2 The "Aleksandar Makedonski" Boulevard

This boulevard is situated on the north-east part of the city. Its renewal was recently approved by the city authorities and was done by the public enterprise "Parks and greenery". With that the new qualitative soil was laid out on the sidewalk near the boulevard and in the jardinières in the split bar of the road where many plants were planted.

Figure 2: "Aleksandar Makedonski" Boulevard

The Figure 2 presents part of the sidewalk greenery of Aleksandar Makedonski Boulevard, where there is tree line of *A. pseudoplatanus* and flower composition of *V. tricolor.*

Here are the plant species of the boulevard.

Plant species at "Aleksandar Makedonski" Boulevar:

- *C. atlantica*
- *Ch. lawsoniana*
- *Chamaecyparis obtusa* (Siebold & Zucc.) Endl.
- *Cryptomeria japonica* (L.f.) D.Don
- *Pinus mugo* Turra
- *Thuja plicata* Donn *ex* D.Don
- *Thuja orientalis* L.*"Pyramidalis Aurea"*
- *Thuja occidentalis* L.*"Smaragd"*
- *Taxus baccata L.*
- *T. baccata."fastigiata"*
- *J. horizontalis*
- *pseudoplatanus*
- *platanoides. "Crimson King"*
- *Betula pendula Roth.*
- *bignonioides* f.*"nana"*
- *F. americana*
- *Fraxinus ornus L.*
- *Populus alba L.*
- *Populus nigra L.*
- *Quercus trojana* Webb
- *Salix caprea* L.
- *T. tomentosa*
- *horizontalis*
- *Euonimus fortunei* (Turcz.) Hand.-Maz.
- *alatus*
- *Hibiscus syriacus* L.
- *Lonicera sempervirens* L.
- *M. aquifolium*
- *P. laurocerassus*
- *Photinia x fraseri* Dress
- *P. coccinea*

- *Viburnum opulus* L.
- *R. rubiginosa*
- *Ageratum houstonianum* Mill.
- *oleracea ,,wild cabbage "Osaka"*
- *argentea*
- *Ch. morifolium*
- *Plectranthus scutellarioides* (L.) R. Br..
- *chinensis*
- *waleriana* f.
- *Iris× germanica* L.
- *M. sylvatica*
- *Pelargonium peltatum* (L.) L'Hér.
- *P. hybrida*
- *T.erecta*
- *Verbena hybrida* Groenl. & Rumpler
- *V. tricolor*

4.3 The "Partizanski odredi" Boulevard

In 2011 together with the reconstruction of the roadway it was renewed the boulevard greenery too. The jardinière along it was rebuilt and new fertile soil was layered down, in order to improve its quality. It was set up an irrigation system which now provides proper conditions for many conifer and deciduous plants planted there. With this reconstruction it was removed the metal fence in the jardinière in "Vlae" settlement. Now, the jardinière is 2113 m long with hydrant net of 552 m. Together with many different plants, there were planted roses along the split bar of the road. This frequent boulevard in some locations is planted with too many species; some of them with dimensions not proper for the place of growth. In few locations because of the dense vegetation the drivers and pedestrians have limited view on the traffic. That is the case with Bunjakovec place where a green market is situated so the frequency of people is very big. In recent time some activities are done in maintaining the greenery of the jardinière plants, so some of them were removed improving the situation with the traffic, proving that way the importance of keeping boulevard greenery in good shape.

Figure 3: "Partizanski Odredi" Boulevard

Figure 3 shows part of "Partizanski Odredi" Boulevard where Bunjakovec market is placed. There is many traffic, and a lot of people trying to get from one to the other side of the boulevard. The dimensions of the plants there interferes the view and the participants in the traffic should be more careful when using the boulevard.

In the jardinière in a split bar and on the sidewalk there are various plants and the list of them is presented below.

Plant species at "Partizanski Odredi" Boulevar:

- *Ch. lawsoniana*
- *Ch. obtusa*
- *C. japonica*
- *P. mugo*
- *T. baccata*
- *T. baccata "fastigiata"*
- *Th. plicata*
- *Th. occidentalis*
- *Th. occidentalis "Pyramidalis"*
- *J. horizontalis*
- *Acer palmatum* Thunb.*"dissectum"*
- *A. platanoides*
- *A. pseudoplatanus*
- *Aesculus hippocastanum*
- *B. pendula*
- *C. bignonioides*
- *F. ornus*
- *P. occidentalis*
- *Prunus avium* (L.) L
- *Q. trojana*
- *S. caprea*
- *T. tomentosa*
- *C. horizontalis*
- *H. syriacus*
- *Lonicera sempervirens* L.
- *M. aquifolium*
- *Ph. x fraseri*
- *P. coccinea*
- *P. laurocerasus*
- *Euonymus japonica* Thunb.
- *V. opulus*
- *R. rubiginosa*
- *A. houstonianum*
- *B. oleracea - "Osaka"*
- *Celosia plumosa* L.
- *Ch. hortorum*
- *Plectranthus scutellarioides* (L.) R.Br.
- *D. chinensis*
- *I. waleriana* f.
- *I. germanica*
- *M. sylvatica*
- *P. peltatum*
- *P. hybrida*
- *Salvia splendens* Sellow ex Schult.
- *T. erecta*
- *V. hybrida*
- *V. minor*
- *V. tricolor*

The high vegetation in the jardinières should be planted minimum 6 m from the pedestrian crossing. Along the boulevard there are planted a lot of trees and shrubs with various dimensions

4.4 The "Jane Sandanski" Boulevard

The renewal of this boulevard in Skopje was similar as the other ones. The greenery there was enriched with trees, shrubs, flower compositions, even floral figures. In the split bar of the roadway it was made a jardinière formed of reinforced concrete elements, long about a kilometer. To irrigate the greenery there was set hydrant net of "drip irrigation" system, and quality soil on which along the boulevard were planted many different plants as it is presented in a list below.

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

Plant species at "Jane Sandanski" Boulevard:

- *Abies concolor* (Gordon) Lindley ex Hildebrand
- *C. atlantica*
- *C. deodara*
- *Cupressus arizonica* Greene
- *pseudoplatanus*
- *pendula*
- *bignonioides*
- *P. orientalis*
- *Q. trojana*
- *T. tomentosa*
- *F. suspensa*
- *P. coccinea*
- *R. rubiginosa*
- *A. houstonianum*
- *B. oleracea "Osaka"*
- *plumosa*
- *P. scutellarioides.*
- *D. chinensis*
- *I. waleriana*.f.
- *M. sylvatica*
- *Portulaca oleracea* L.
- *P. hybrida*
- *S. splendens*
- *Jacobaea maritima* (L.) Pelser & Meijden.
- *T. erecta*
- *V. hybrida*
- *V. minor*
- *V. tricolor*

Specific type of flower compositions are floral figures of storks, swans, butterflies and a snail that are set in the jardinière of the boulevard. They complete the decorative aspect of this kind of greenery.

Figure 4: "Jane Sandanski" Boulevard

The Figure 4 shows "stork" floral sculpture which is one of the three positioned in the jardinière in the split bar of the boulevard. They are especially effective considering their dimensions. This one is planted with *V. tricolor* and it is set among the group of roses *Rosa rubiginosa* and *A. concolor.*

5 CONCLUSION

The boulevard greenery is one of the most important categories of greenery in an urban environment. It has direct influence on improvement of the air and in same time is decorative element in the city structure.

The subject of research of this article is boulevard greenery on four boulevards of the wider central area: "Ilinden", "Aleksandar Makedonski",."Partizanski odredi" and "Jane Sandanski". They are most frequent and can be considered as the most important city arteries.

They are planted with species that are more or less identical in all of the researched boulevards, mostly because they come from the same nursery garden. Comparing the four boulevards, their central jardinières are mostly planted with groups of trees and shrubs, rarely with solitaires. In some of them ("Partizanski odredi") plants are too crowded, so the public enterprise should maintenance the greenery more carefully, because dense vegetation in part of it bothers regular traffic activity..

At "Jane Sandanski" boulevard the vegetation is in good shape because of the constant care of the workers of the public enterprise. "Parkovi I zelenilo". There and in the greenery of "Ilinden" boulevard are set up floral sculptures in form of:: turtle, snail, swan, stork and butterfly, making that way the areas more decorative.

There are other aspects of human behavior in the urban living considering the frequency and importance of the boulevards so the vegetation is mostly in a role of improvement of the urban environment.

The whole sum of green areas is 1,302,457m^2, boulevard greenery is 8,939 m^2,, the suburban greenery is 9 227 m^2 and sport-recreate centers have 425 678 m^2 greenery.

The „Ilinden", ",Aleksandar Makedonski", "Partizanski odredi" and „Jane Sandanski".boulevards were recently renewed where:

- new layers of quality soil were set,
- the hydrant net with irrigation system was reconstructed,
- the old trees in tree lines were replaced with new ones
- new trees, shrubs and flower plants were planted in the jardinières and near the sidewalks.

The accent was put on species planted in the split bar of the roadways, in the jardinières, as well as on the sidewalks of the boulevards. There were planted shrubs and trees (with bigger and smaller dimensions). Also, there were situated flower figures in forms of: butterfly, turtle, swan, stork and snail. Some of them were situated in the greenery on locations along the boulevards, near the sidewalks. The base for flower forms was made of wire constructions filled with turf where flower compositions were set up.

Planting trees, shrubs or flowers in order of editing the boulevards greenery is according urban planning of which they should be set on proper locations considering their morphological characteristics and ecological needs considering the specifics of the locations/habitats. They should be resistant on the negative affection of the anthropogenic factor and be decorative in the same time. To fulfill all the tasks take care the public enterprise "Parkovi I zelenilo" which maintenance the public greenery in the City of Skopje.

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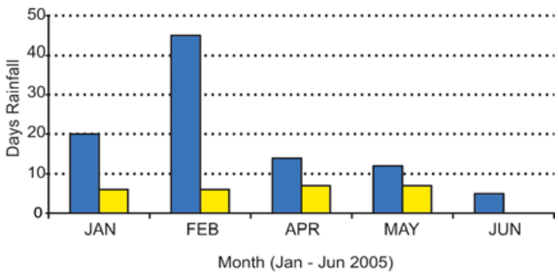

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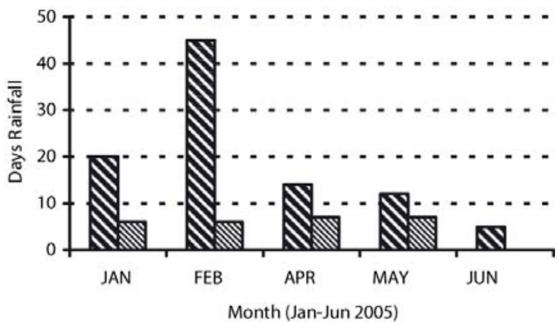

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Biomass Sources	Quantity	Moisture	Residue
Sewage Sludge	1.86	1.73	1.40
Septage	0.32	0.28	0.16
Fruit Pulp	3.78	3.89	4.02

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Меѓународно научно списание	International Scientific Journal
Год. 45 / Стр. 1-36	Vol. 45 / Pag. 1-36
Скопје, 2014	Skopje, 2014
Online ISSN 1857-9507	Online ISSN 1857-9507
УДК 630	UDC 630
УДК 635.9	UDC 635.9
УДК 674	UDC 674
Издавач	**Publisher**
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