CONTENTS

Brief communication

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DIFFICULTIES AND SOLUTIONS IN ASSIMILATION OF WOOD FROM TEMPORARILY INACCESSIBLE FOREST EXPLOITATION BASINS IN THE EASTERN BULGARIA

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Abstract

There are a number of problems within the temporarily inaccessible and hardly accessible forest exploitation basins, as the lack of a road network, lack of information about how many inaccessible basins are there, where are they located and what kind of a road network should be necessary for their exploitation. The present paper deals with the state of the inaccessible and hardly accessible forest exploitation basins in the Eastern Bulgaria (total 53) situated on the territory of the Regional Forestry Directorates (RFD) of Varna, Shumen, Sliven, and Burgas). The draft-traces of the new forest roads that should be constructed within the forest basins. The road locations have been adjusted and different variants of technological schemes, appropriate for the different working conditions and types of cutting were proposed. The total area and the resource, as well as the provided uses have been determined. The expenses required for logging have been calculated, as well as the expenses for road construction. The expected incomes, outcomes, and the prime costs of the wood planned for harvesting were calculated as well. The mountainous orography and the low density of the forest-road network within the basins provided opportunity for a choice between two types of machines to be used (a specialized tractor and a short cable systems), or a combination of both.

Key words: forest-road network, inaccessible or hardly accessible forest basins, logging, technological scheme.

Introduction

The analysis of terrain characteristics and their influence on different production stages is of crucial importance for the entire study necessary in a given forest region where wood harvesting technologies are comprised. It is also important particularly in the assessment of the available forest road network and for the planning of the tractor roads (Kramer 2001). The road network density should be 25 m•ha^{-1} in the hardly accessible mountain areas. Such density is enough for using of mobile cable lines. Meanwhile, after introducing the cable lines, the construction of tractor forest roads will be reduced. It should be taken into consideration that technology is the most harmful to the forests, as the resulting consequences and the ecological damages are undoubtedly great (Pičman and Pentek 1999). What should be provided, before planning of a haulage by tractors on steep slopes, is the assessment of the probability of erosion and the possibility for the use of alternative cable systems (Schiess 1999).

The availability of a network of forest roads on steep terrains will stimulate the use of mobile cable lines (FAO 1999). According to FAO (1998), the cable systems are less limited by the slope and more by the terrain shape. They are the most appropriate for areas where the slopes are between 30 % and 100 %. In the future, the cable lines of a length from 200 to 400 m will prevail, as well as the fan-shaped installation of cable lines in areas where it will be possible, depending on the conditions. According to the assessment of the actual state of wood harvesting, the one that will be done using cable lines should be developed further to keep its competitiveness in the difficult conditions of the mountain areas (Trzesniowski 1998).

The purpose of this study was to establish the state of the temporarily inaccessible basins, also known as “closed basins“ in the Eastern Bulgaria, and the possibilities of the utilization of the wood harvested there.

Materials and Methods

This study focuses to the temporarily inaccessible basins, the forest-road network related to the them, technical means and technologies used in the logging in the Eastern Bulgaria. It is of particular interest to study whether the above mentioned technical means and technologies are appropriate for the wood harvesting and transportation within the basins.

The methodological scheme addresses several questions: 1) The state of the forest exploitation conditions; 2) The state and the characteristics of the basic production stocks which are at disposal of wood harvesting forest companies; 3) The technology and organization of the work.

The nature of the relief in the Eastern Bulgaria is rather variable. The northern slopes of the main ridge are steep and rough, especially in its western part. The southern slopes have also very steep ridges. The terrain in the river watersheds is mountainous, consisting of short but steep ridges and slopes. The remaining part of the territory situated on the spurs of the main ridges is of a semi-mountainous nature, with rounded and vaguely outlined ridges, sharply cut glens and steep inclined slopes. The aspect of the terrain eastward presents clearly outlined ridges and plain-type flat uplands, passing into a hilly nature, outlined by slopes, being almost plain, delineated by plane ridges, and at short distances only, to the seaside, inclined and steep slopes dip downward. Strandzha is generally low mountain. It is slightly folded to the sea. There are numerous low and rolling ridges, part of which rise more evidently and are better delineated, along with a number of glens, thus rendering complex and rough character of the terrain. The orography in this part is broken and hilly, while in the interior part of Strandzha, the relief is of hilly-mountainous nature, with smooth ridges and deeply cut glens. Numerous secondary ridges, cut by smaller and larger glens, deeply incised into the terrain, descend from westward to eastward, rendering a highly rough character of the orography.

Results and Discussion

There are several parameters of the locality affecting strongly the mechanization of wood harvesting. Of particular importance are the slope of the terrain and orography of the locality (roughness etc.) resulting in hardly accessible basins. Tractors and animal haulage power are used in smoother terrains while cable lines and animal haulage power are applied in steeper ones.

No good economical results can be achieved without establishment of a modern forest road network and without mechanization of the technological processes in the plantations. The density of the forest road network is particularly important, because it is still too scarce in Bulgaria, mostly due to the mountainous character of our forests.

The reduced use in Bulgarian forests is partly due to the scarce and insufficient road network within the temporarily inaccessible basins, and this, together with the unsteady market of wood are the main reason of not harevesting 500,000 m^2 of the planned volume annually.

Table 1 shows the types and the number of the machines in the Regional Forestry Directorates in Eastern Bulgaria. It can be seen that in RFD Burgas the haulage was done mostly by animal power (76 %) and recently, due to the lacking market of coarse wood, the animal power use reached even 90 % at some moments. The horse power haulage in the RFD Varna was approximately 40 %, followed by the use of tractors – 24 %, and the remaining part of wood in the cutting areas was loaded by hand. The RFD in Shumen was characterized by the highest use of mechanized haulage – 85 %, while in the RFD Sliven the use of animal power haulage was concentrated in the lower altitudes – 85 %. In the upper mountainous regions, i.e. within the Balkan Range, it was only about 18 %.

The tractors used were “Universal-651” and some single “LKT–80/81”. The cable systems were “TBC–500” and “Koller-K-300”, and the loading was done predominantly by Shipka hydraulic cranes. “DT–75” and “C–100” tractors were used as bulldozers for the maintenance of forest roads.

Temporarily inaccessible forest-exploitation basins in the Eastern Bulgaria

The total area, stock and the use were determined within the temporarily inaccessible forest exploitation basins. The costs for cutting and haulage, for tractor roads, incomes and profit, as well as the prime cost expected for wood to be harvested were calculated (Table 2). Besides,

Table 1. Total number of the used basic machines for logging in the Eastern Bulgaria.

Regional Forestry Directorates	Tractors, no	Cable line systems, no	Loaders, no	Bulldozers, no
Varna	12	–	22 and 8 cranes mounted on trucks	6
Shumen	36	1	26 and 4 cranes mounted on trucks	13
Sliven	30	2 (1 for discontinuous operation)	18 and 7 cranes mounted on trucks	10
Burgas	21	1 (for discontinuous operation)	16 and 2 cranes mounted on trucks	4
Total	99	4 (2 for discontinuous operation)	82 and 21 cranes mounted on trucks	33

Table 2. Forest exploitation basins of a temporary inaccessibility in the Eastern Bulgaria.

Regional Forestry Directorates (RFD) and the related State Forestry Services	Numbers of the basins	Total area, ha	Total resources, m^3	Provided use, m^3	Total costs provided for wood exploitation, BGN	Technological schemes. Primary transport with	Working conditions
RFD Varna							
Staro Oryahovo	1	651.0	165,210	13,045	460,810 (226,000)	Tractors and animal hauling power.	Inaccessibility due to deep gullies, missing roads.
Tsonevo	5	1,363.1	229,265	36,415	2,675,620 (1,041,000)		
RFD Shumen							
Smyadovo	5	1,887.4	240,785	44,200	1,283,000 (330,000)	Specialized tractors and cable way system.	Steep terrains where deep gullies are available.
Varbitsa	1	760	116,730	15,428	1,481,910 (80,000)		
RFD Sliven							
Tvarditsa	16	1,865.9	271,320	36,978	3,182,450 (2,663,000)	Specialized tractors and cable way system.	Old cart-ways available therein, in a bad condition.
Kotel	9	2,124.4	530,340	63,840	1,954,051 (390,000)		
Ticha	3	1,169.0	331,615	46,220	1,795,000 (500,000)		
RFD Burgas							
Tsarevo	3	1,450.7	284,665	56,933	1,418,237 (194,530)	Tractors and animal hauling power.	An area of a difficult accessibility within an inter-border facility.
Zvezdets	2	5,972.8	256,685	31,340	1,125,305 (397,165)	Specialized tractors, cable way system and animal hauling power.	A highly rough terrain, missing roads, non kept old roads, missing bridges.
Malko Tarnovo	8	2,214.1	471,280	42,815	1,087,430 (145,500)		
Total	53	19,457.7	2,897,895	387,214	16,463,813 (5,967,195)		

Note: There are costs provided for road building and repair, indicated in the brackets.

the traces of both the old forest roads and the new ones that have to be constructed for taking the wood from the temporarily inaccessible basins, have been plotted on the forestry map. The mapping of the traces was done after visiting each basin, considering also the old forest motor-car roads, used tractor and carts, the old traces of cable lines, minimal damage during the road construction and the services of the entire basin (including all the forestry activities undertaking like wood harvesting, afforestation, forests fires and others). At last, all that has been done taking into account the costs required for projecting and construction. A model scheme for exploitation of basins is shown in Figure 1.

After examining the target basins, further analysis will be required to adjust where the construction of new roads would be profitable considering the forest-exploitation conditions, planned volume and also the requirements for close-to-nature management and biodiversity conservation.

Infrastructure Required

It should be mentioned that there are uncovered roads (earth roads). In some cases and places their foundation could be stabilized using quarry materials or admixing mineral substances.

The cost of the forest roads depends mostly on the inclination of the terrain and the density of the hydrographic network. The most capital-consuming construction and repairment works are the excavations in rocky soils by blasting, concrete laying and construction of facilities and road coverage.

The average cost per 1km forest road varies within a very large range, depending on the terrain conditions (terrain category) and the road slope. If the terrain conditions are subdivided in three categories as a function of the cross inclination of the terrain, the limits within which the cost of 1 km forest road changes, may be considered appropriate, as presented in Table 3.

Table 3. Prices determined for the construction of 1 linear meter of a truck forest road in Bulgaria (data resulted from practice).

Average transverse slope of the terrain	Road category	Width of the road coverage + road bed, m	Limits of costs, BGN
up to 15°	ground	3–4	2–10
	stabilized	3–5	60–80
15° – 30°	ground	3–4	10–20
	stabilized	3–5	100–140
more than 45°	ground	3–4	20–40
	stabilized	3–5	150–200

Note: In extremely difficult conditions where a breach of rocky soils is to be done and props (retaining walls) and others are to be erected, the costs may increase with 40 %.

At the moment, the project design of forest roads within the “closed basins“ is highly restricted. There are a few RFDs where roads are fully or partially constructed based on a preliminarily elaborated project. In the majority of cases there are only temporary motor-car roads to be constructed.

Besides, the construction of forest road network should be planned further

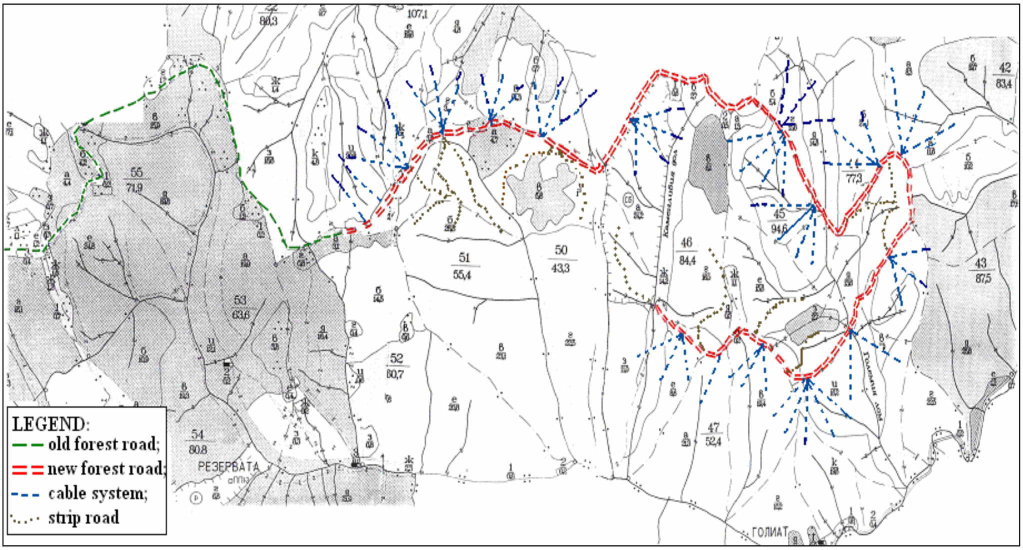

Fig. 1. Map of one of the temporarily inaccessible basins.

in conformity with the technology selected during the second phase of the wood harvesting, particularly within steep enough forest areas where cable lines are to be introduced. Presumably, a different approach should be applied to the procedure of the forests exploitation and to the different parameters implemented to the analysis and selection of the best traces for forest roads.

Conclusions

1. The lack and the worsened state of the technical equipment, technologies and organization of the work resulted in fragmentation increased number of the cutting areas, hence resulting in the extension of the distances for haulage, decrease of the unit volume and the cut mass, raise of the production costs etc., which directly affect the level of development of the wood harvesting branch.

2. At the moment, the forest-road network density is unable to guarantee efficient conditions for a stable management of the forests and forest wood production.

3. There is a need of construction of new forest roads, thus providing adequate access to the temporarily inccessible basins, or repairment of the old roads, including the adjacent facilities, in order to reach a forest road network density more than 7–8 m•ha^{-1}. At very first time, it would be enough for the use of mobile cable systems of a length up to 800 meters, in a combination with the specialized tractors for haulage of the harvested wood.

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PINE RESIN SECTOR IN PORTUGAL – WEAKNESSES AND CHALLENGES

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Abstract

In the past, Portugal was an important producer and exporter of crude resin (pine oleoresin) obtained from living trees. The main species used as a source of Portuguese naval stores until today is *Pinus pinaster* Ait., one of the most productive resin species. With the increase of labour costs in the forest, the international market competition from China and Brazil and the occurrence of severe forest fires, the importance of both resin yield and industry has sharply diminished. Despite of the decrease of *Pinus pinaster* area in last decades, this species still holds an important position in Portuguese forest – 885,019 ha, according to the last National Forest Inventory (NFI). In European Union (EU), Portugal remains one of the few countries with the capacity to supply and fulfil the special needs of some industries: for instance turpentine for perfumery and rosin for the manufacturing of tyres. In the present paper we estimated the potential yield capacity of the Portuguese maritime pine forest based on the NFI data, and made a summarized SWOT analysis, having in mind the weaknesses and the virtues of the remaining resin economic sector.

Key words: gum naval stores, pine resin industry, resin yield, SWOT analysis.

Introduction

Portugal was an important producer and exporter of pine oleoresin, with yields higher than 100,000 tonnes per year before 1980 (CESE 1996). As an example, in 1987 Portugal exported 110000 tonnes of naval stores with a total value of 61,000,000 USD (Leite and Morais 1988). Several factors determined the decline of this activity, namely the rise of labour power costs in Europe, concurrence of China and Brazil raw materials, wide occurrence of forest fires, which affected particularly the age structure of pine stands, and the lack of technological innovation in pine tapping operations.

Despite these setbacks, the growing demands of the world market and the European in particular, the need to maintain rural employment and avoid desertification, together with the resin sector growth potential in Portugal, require a suitable development of naval stores production. Therefore, it is important to assess the potential resin yield of Portuguese maritime pine forest. In this paper all the estimations were based on data from the most recent National Forest Inventory (NFI).

Characterization of Portuguese Forest

The Portugal mainland forest area is about 39 % of the mainland territory. According to the NFI data (AFN 2010), pure and mixed dominant stands of maritime pine occupy an area of 885,019 ha which is 28 % of the mainland total forest area.

Along the years considered in Table 1, in spite of the existence of changes in strata classification criteria as well as differences in the chronological series for different species (Sardinha et al. 1994), several considerations can be done about the evolution of forest stands area.

Thus, the analysis of available data from 1874 to 2005 shows a steady increase of the pine and cork oak until 1974. However, since 1974 the forest area has not increased significantly – only 4.6 %, and on the contrary, in the last ten years (from 1995 to 2005) there was a slight decrease of forest stands area, from 3,201,131 ha to 3,175,348 ha.

Even more worrying, however, is the strong decrease in maritime pine areas,

Table 1. Evolution of forest stands area in Portugal Mainland in the last 125 years (1874–2005), (1000 ha).

Year	*Pinus pinaster*	*Quercus suber*	*Quercus rotundifolia*	*Quercus* spp.	*Castanea sativa*	*Eucalyptus* spp.	*Pinus pinea*	Other species	Total
1874 (1)	210.0	370.0	–	60.0	–	–	–	–	640.0
1902	430.2	366.0	416.7	47.0	84.0	–	–	612.6	1956.5
1928	1131.6	559.7	380.0	107.9	85.2	–	–	67.0	2331.4
1934	1139.2	740.6	380.0	108.0	85.2	–	–	67.0	2520.0
1939	1161.0	690.0	360.0	108.0	80.0	–	–	68.0	2467.0
1956 (2)	1253.7	648.6	615.3	132.0	–	58.0	–	55.3	2762.9
1966 (3)	1287.6	636.8	578.6	–	25.6	98.9	–	164.3	2791.8
1974	1299.0	680.4	534.4	67.8	30.2	243.1	–	181.7	3036.6
1985	1248.6	659.8	464.2	85.7	32.1	386.2	–	209.0	3085.6
1990	1252.3	664.0	464.7	112.1	31.1	385.8	–	198.2	3108.2
1995	976.1	712.8	461.6	130.9	40.6	672.0	77.7	129.4	3201.1
2005	885.0	715.9	412.9	150.0	30.0	739.5	130.4	111.6	3175.3

(Azevedo 1996, DGF 2001, AFN 2010)

(1) *Pinus pinaster* stratum includes also other pines; *Quercus suber* stratum includes *Quercus rotundifolia* stands, and *Quercus* spp. stratum includes *Castanea sativa* stands.
(2) *Castanea sativa* stands were included in *Quercus* spp. stratum.
(3) *Quercus* spp. stands and another species were included in Other species stratum.

about 32 %, during the last 30 years, as shown on Figure 1.

On the other hand, since 1956 the area of eucalyptus stands, which until then had no significant value, started increasing rapidly (since the 1960s until now about 650 %).

It should be also emphasized that although forest land in Portugal suffered over the years several changes, during the last 30 years its global area stabilized slightly over 3,000,000 ha, mostly due to the replacement of conifers (mainly *Pinus pinaster*) by fast-growing broadleaves (mainly *Eucalyptus globulus*).

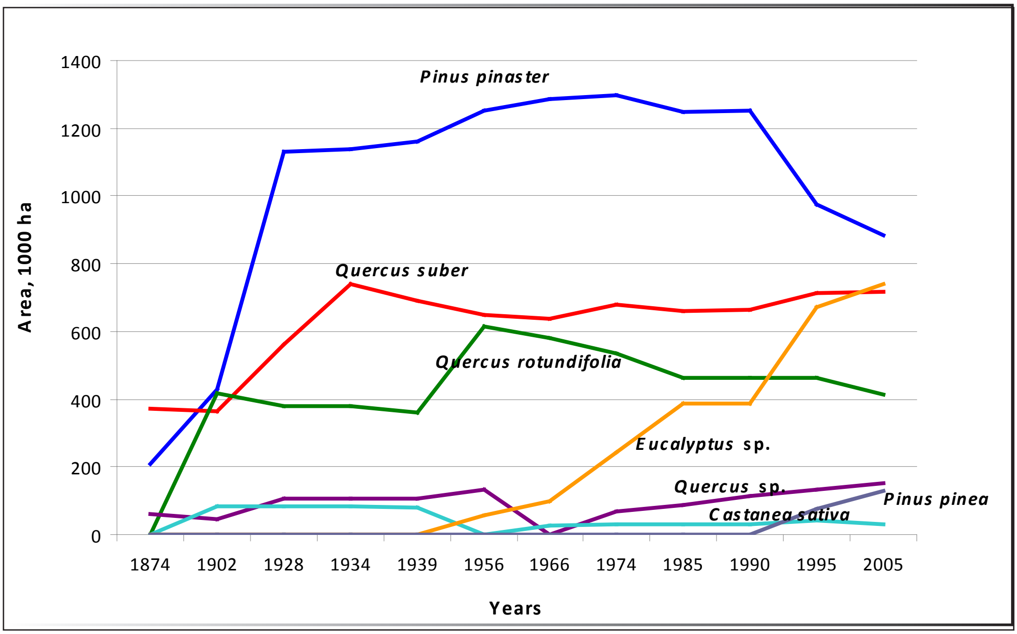

Fig. 1. Evolution of land occupation by forest species in Portugal mainland.

Table 2. Forest land ownership structure (1000 ha).

Forest land ownership	**1980**	**%**	**2005**	**%**
Private forests	2629.5	85	2318.0	73
Industrial owners	185.5	6	317.5	10
Communities and other owners	202.1	7	349.3	11
			95.3	3
State forests	68.1	2	95.3	3
Total	3085.2	100	3175.3	100

(IPF 1991 & Barreiro et al. 2010)

Concerning forest land ownership (Table 2), the structure remained nearly unchanged since 1980: 85 % of the forest land in Portugal was under private ownership, while the State forests only attained 2 %. This fact made Portugal one of the EU countries with the lowest public forest area and has been an obstacle for an adequate management of the forest territories, including resin yield planning and improvement. Nowadays the situation is basically the same, with the fraction detained by the industrial owners rising from 6 % to 10 %.

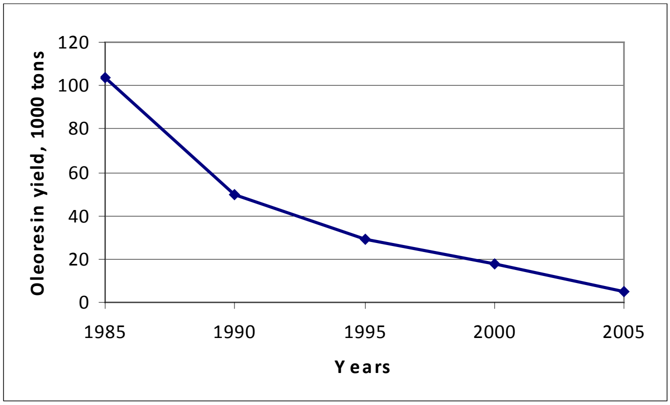

Fig. 2. Evolution of oleoresin yield in Portugal (INE 2010).

Evolution of Oleoresin Yield and Trade Balance of Naval Stores in Portugal

As mentioned above, until 1980 Portugal had oleoresin yields higher than 100,000 tonnes per year. However, the evolution of oleoresin yields since 1985 (Figure 2) shows that the yield decreased heavily, to less than 50,000 tonnes until 1990, and further on the reduction continued reaching extremely low values. Nowadays, according to estimates of the industrial sector, the yield is stabilized at a very low level, around 5,000 tonnes per year.

In the past resin products represented around 10 % of the forest sub-sector exports in value; however, until 2005 this fraction decreased sharply to 1 %.

Figure 3 shows the evolution of import/export balance of Portuguese naval stores in the last years.

During the last 30 years of the 20th century, resin products as a whole contributed positively to the import/export balance. However, this situation was reversed from 2005 on. Nevertheless for some of those products, for instance turpentine and rosin derivatives, the exportation trend is increasing.

Evaluation of the Potential Area for Resin Tapping

The collecting of resin is generally performed on mature trees, mainly *Pinus pinaster*, in pure or dominant stands, thus excluding young trees. That is the reason why the area of maritime pine considered for tapping – 826,075 ha, in the calculations below is lower than the one referred in Table 1 – 885,019 ha.

According to Portuguese law, resin tapping can only begin when the tree

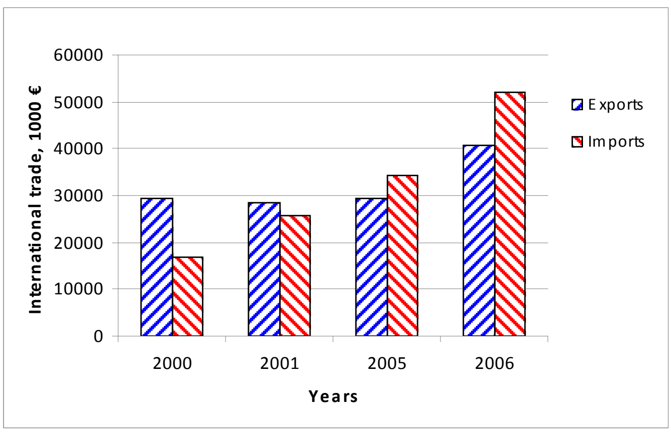

Fig. 3. Evolution of international trade of Portuguese naval stores (DGF 2003; DGRF 2005, 2007).

reaches minimum DBH of 25.5 cm. Two tapping regimes are possible: long term tapping, which begins early in the life of the tree and takes place until final cut, and tapping before final cut, which occurs only in the last 3–4 years before final cut.

In order to estimate the potential oleoresin yield from maritime pine forest in Portugal the following assumptions were considered:

– Total potential area for resin tapping was the area occupied by the trees with the appropriate diameter for exploitation (i.e., more than 25.5 cm);

– Yields per tree from 1 to 4 kg of oleoresin (these values were obtained in tapping essays which took place previously);

– Densities compatible with good or regular conditions for oleoresin production: in pure stands 200, 300 and 400 trees per hectare, and in mixed dominant stands, according to medium stand density (AFN 2010), about 63 % of those values;

– Two tapping scenarios, a less[1] and a more intensive one[2].

According to the more recent NFI, the total area of maritime pine stands, for long term and before final cut tapping is 66,609 ha for pure stands and 15,038 ha for mixed dominant. However, the estimations based on the assumptions referred above show potential resin tapping areas considerably higher in both scenarios (Table 3).

Estimation of the potential areas for tapping together with all possible combinations of both variables, yield per tree and stand density, lead to the following boundaries for potential resin yield in Portugal mainland (Table 4).

Three percentages of potential area were considered to calculate different potential resin yields. It can be stated that for 30 % class of potential area, some values are very low. However, considering 50 % class, most values are already acceptable to assure a stronger economic resin sector, namely in long term tapping. In fact, during the golden years of resin tapping, when Portugal was responsible for the greatest values of resin yield, the area submitted to exploitation was about 50 % of the total pine forest area.

Table 3. Area of maritime pine stands for tapping, estimated for scenarios 1 and 2; tapped area according to NFI 2010.

Stand Composition	Tapping (maritime pine)				
	Scenario 1		Scenario 2		NFI 2010
	long term	before final cut	long term	before final cut	
Pure, ha	55412.1	18854.3	87329.8	41541.5	66609.0
Mixed dominant, ha	15745.3	9593.3	23300.5	16499.8	15038.0

SWOT Analysis: an Approach

A summarized SWOT analysis was performed in order to identify both strengths

[1] Trees with DBH 30–39 cm in “long term tapping” and tapping “before final cut” with DBH>40 cm.

[2] Trees with DBH 25.5–34 cm in “long term tapping” and tapping “before final cut” with DBH>35 cm.

Table 4. Potential resin yield in Portugal mainland, tonnes.

Potential area, %	Tapping regime	Less intensive (1)		More intensive (2)	
		min	max	min	max
100 %	Long term tapping	26108	156646	40767	244600
	Tapping before final cut	4972	39776	10374	82994
50 %	Long term tapping	13054	78323	20383	122300
	Tapping before final cut	2486	19888	5187	41497
30 %	Long term tapping	7832	46994	12230	73380
	Tapping before final cut	1492	11933	3112	24898

and weaknesses of the resin sector and to point out the available opportunities and existing threats on the external environment.

Key pieces of information were grouped into two main categories: *strengths* and *weaknesses* (internal factors to the organization) – personnel, finance, manufacturing capabilities; *opportunities* and *threats* (presented by the external environment) – macroeconomic matters, technological change, legislation and socio-cultural changes (Détrie 1993). An inventory of most relevant factors and trends which frame this activity was made, based on official statistical data and knowledge of agents interviewed in a previous work (Palma 2008).

Oleoresin Production in the Field

Forest fires, leading to a deep unbalanced age and dimensional structure of pine stands in Portugal mainland, together with Pine Wilt Disease (*Bursaphelenchus xylophilus*) incidence, have diminished the area suitable for resin tapping.

Resin collecting is a very labour-intensive activity, which became unsustainable along the years because of the rising costs of field labour and the high prices of pine stands hiring[3]. Along the years no technological advances were achieved in resin tapping operations: the work is very hard, requiring specific skills and there are few workers available to perform it (Coppen and Hone 1995). As a result, cost prices of the national raw material are very often higher than those of imported gum rosin or turpentine.

World Production and Markets

China is by far the biggest world producer, consumer and exporter of gum naval stores – it is responsible for 70 % of the world production and controls efficiently the world market and prices. As a result of this price fluctuation, the industry undergoes cyclical instabilities.

Obviously Portugal as a small produc-

[3] Pine stands are usually hired for tapping at high prices. There is, obviously, a conflict of interests between landowners and industry, landowners want to preserve wood quality and the resin industry wants to maximize resin yield.

er does not control the market and cannot guarantee the supply of its own internal demands. Import from China and Brazil is imperative to fulfil the demands of the established industry.

However, for some specific purposes chemical industry still prefers Portuguese turpentine and rosin, based on specific quality requirements.

The main destinations for Portuguese gum resin exports are European countries: Germany, Italy, Spain, Switzerland, France and United Kingdom.

Industry and its Condition

Human resources in the sector have a low level of training but have a good knowledge of the resin products.

The total number of plants for oleoresin manufacturing in Portugal is very low and still decreasing. Currently there are 17: six for first transformation (rosin and turpentine) and the other eleven for derivatives (Anastácio and Carvalho 2008). The two types of plants are very different. The first ones are generally small, with a weak financial structure and low productivity and technological conditions. The second ones are considerably larger and are equipped with modern technology, making them competitive in markets with growing quality demands.

Tables 5 and 6 summarize the issues related to SWOT analysis.

Final Comments

As written above, the yield capacity of Portugal for gum naval stores suffered a strong blow, but the existing pine forests still have the potential to increase significantly oleoresin production.

In addition, there is a growing demand of these products in the world, particularly

Table 5. SWOT Matrix: Strengths and weaknesses.

STRENGTHS	WEAKNESSES
➢ High quality and specificity of the raw material	❖ Small dimension of companies, with inadequate equipments
➢ Contribution to increasing the profits of forest owners	❖ Non-solved environmental issues (pollution problems)
➢ Maintenance of rural employment combined with prevention of forest fires	❖ Low manpower qualification
➢ Resin tapping of a high productive species, *Pinus pinaster*	❖ Absence of suitable trade chains; strong dependence on external intermediaries
	❖ Low innovation capacity (no efforts to mechanize resin tapping)
	❖ Under exploitation of pine stands

Table 6. SWOT Matrix: Opportunities and threats.

OPPORTUNITIES	THREATS
➢ Growing apprehension of consumers with environmental concerns: resin products are natural and renewable ➢ Raising price of crude ➢ Spanish interest in maintaining the Iberian resin sector (efforts to develop new mechanized resin tapping devices) ➢ Existence of modern plants for manufacture of oleoresin derivatives; establishment of links between them and resin workers and first transformation operators ➢ New products outcome (insecticides and wood preservatives)	❖ Existence and emergence of substitutes for traditional uses of gum resin products ❖ Absence of guaranteed prices for the raw material oleoresin (marked price fluctuation during a season) ❖ Excess of punitive laws in the present crisis context, leading to manpower drain

in Europe. For instance, the recent raising value of gum turpentine as a result of the increased demand may lead to a stimulation of the resin sector as a whole. A positive factor is also the interest and efforts of Spain to develop a mechanized system for both resin tapping and collecting, in order to maintain and expand their resin sector.

The present economic crisis may also contribute to an increased interest in oleoresin exploitation. Although the unemployment is the main cause for this interest, we should point out one of the most important virtues of the resin tapping activity: it maintains rural employment avoiding desertification, and hence preventing the rising impact of forest fires.

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QUALITY AND DEVELOPMENT OF CONTAINERIZED SEEDLINGS AND STANDS OF AUSTRIAN BLACK PINE (*PINUS NIGRA* ARN.) IN THE REPUBLIC OF MACEDONIA (FYROM)

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Abstract

In this paper features of container "Paperpot", "Yucosad", "Pirosad" and bare root seedlings, used in afforestation in the R. of Macedonia, are presented. Morphometrical features of seedlings were measured and statistically compared. A further development of Austrian black pine trees in stands and in experimental fields, raised from container and bare root seedlings in different ecological conditions was investigated. Height and diameter of trees were measured, and their vitality was estimated. Container type and its volume do not directly influence the seedlings quality. All investigated container seedlings have more or less satisfying features, independently on container. Survival, development and vitality of young stands depends more on site conditions and planting techniques; the influence of container type is not expressive. Survival and vitality of younger stands is quite poor. Trees in older stands develop more or less normally, influenced mostly by site conditions. There is not crucial influence of container type on development and vitality of stands recorded.

Key words: Austrian black pine, bare root seedlings, container seedlings, growth parameters, stands**.**

Introduction

In the Republic of Macedonia, ca. 20 % of reforestation and specially afforestation, has been executed with container seedlings. Since 1974, container "Paperpot" has been used, while a domestic hard-plastic container "Yucosad" was developed few years later and is widely used ever since. Other containers ("Plantagrah", "Makosad", "Pirosad" etc.) are rarely used. The development of stands raised by "Yucosad" seedlings has been under suspicion because of root deformation. Consequently, poor development, and finally dying of "Yucosad" Austrian black pine stands, at age approx. 6–8 years, has been prognosticated (Popovski 1985).

In Macedonia investigations of container seedlings were executed by Popovski (1986), Kolevska (1995), Kolevska et al. (2006), and development of Austrian black pine stands by Kolevska (1995), Trajkov et al. (2002). Container seedling features and development of stands raised by container seedling worldwide were investigated by many researchers (Van Eerden and Arnott 1974, Lokvenc 1985, Scarrath 1991, Jones et. al. 2002, etc).

The aim of this investigation is to establish whether the container seedlings influence the growth and vitality of trees. For this purpose seedlings of Austrian black pine produced in containers “Paperpot”, “Yucosad” and “Pirosad” and as bare root, were analyzed. The further development of trees of respective seedling types, in stands and experimental fields, with different age and from various ecological conditions in the R. of Macedonia, was analyzed.

Materials and Objects

There were analyzed 1+0 Austrian black pine seedlings, produced in containers “Paperpot” (FH 508, vol. 120 cm^3), “Yucosad” (hard-plastic, bullet-shape, h=10cm, upper d=3.8 cm, volume=70 cm^3) and “Pirosad” (hard-plastic cylinder-shape, with a plastic cone-shape insert in the lower part of the container for better distribution of the roots, h=12 cm, d=5 cm, volume ca. 160 cm^3). As control, 1+0 bare root seedlings were analyzed. There were analyzed 30 seedlings in 4 replications, i.e. total of 120 seedlings of each seedling type.

The investigation of trees was executed both in stands, planted during regular afforestation activities of the forest operative, and in experimental fields.

Trees in 15 stands from different localities in Macedonia were analyzed. Trees (stands) originated from Paperpot, Yucosad and bare root seedling stocks. Stands develop in different ecological conditions: altitude: 250–1300 m, soil: Eutric Cambisols, Distric Cambisols, Alluvial and Rendzinas. Soil preparation: generally by opening a furrow; planting technique: into a notch or a small hole, by various planting tools.

Apart from these 15 stands, development of container (Paperpot, Yucosad, Pirosad) and bare root trees was analyzed in 4 experimental fields (A, B, C and D). Within each experimental field, container and bare root seedlings were planted by the same planting technique in the same ecological conditions.

Total of 19 stands and experimental fields of age 4–19 years were analyzed. On each stand, i.e. experimental field, 11–30 trees, i.e. a total number of 677 trees were measured and analyzed.

Methods

The following parameters of seedlings were measured: height of shoot (mm); No of lateral buds, root collar diameter (mm) and weight of shoot and roots in absolute dry condition (g).

The following parameters of trees were measured: height of shoot (cm), root collar and stem diameter at 1.3 m (cm). The annual height and diameter increment were calculated. A survival, vitality and stability of trees were estimated. Statistical analyses were executed by SPSS program; ANOVA and t-test were used to compare the means.

Abbreviations used in this paper have the following meaning: PP=Paperpot; YS=Yucosad, PS=Pirosad, BR=Bare root; H=height, AHI=annual height increment, RCD=root collar diameter; $D_{1.3\ m}$=diameter on 1.3 m; ADI=annual diameter increment; WADC=weight in absolute dry condition; N=number of analyzed trees; X=mean; SD=standard deviation; vitality: 1=poor, 2=medium, 3=good; *=statistical significance ($p<0.05$).

Results and Discussion

1. Seedlings 1/0

Parameters of 1+0 seedlings are presented in Table 1. Statistical significance of the means is tested for H and RCD. Compared to BR seedlings as control, only PP seedlings are statistically higher. BR seedlings have bigger RCD than all other seedlings types.

2. Trees in stands and in experimental fields

Results of the investigation of the trees are exposed summarily, both for stands and experimental fields, separately for each seedling stock type, in Tables 2–5. Results are presented starting from youngest trees. Since part of the investigation was executed in 4 experimental fields, where the technique of establishing each experimental field was the same and the trees develop in the same ecological conditions, statistical testing of means is executed. For this purpose, morphological features only for the trees from experimental fields are repeated and results of statistical testing are presented in Tables 6–9.

Results presented in Tables 2–5 show that trees of all seedling type origin develop more or less normally, i.e. according to the age and ecological conditions of the stand (experimental field). Young trees have generally poor vitality, while older trees show good one.

2.1. “Pirosad”

Trees in two 4-year-old experimental fields were investigated. Height of shoots and RCD and resp. increments do not vary in wide range. Trees have medium vitality (Table 2).

2.2. “Paperpot”

Results of investigating trees from 7 stands and 4 experimental fields are presented in Table 3. The less stem height

Table 1. Basic morphometrical features of the seedlings.

Seedling type	H, mm		RCD, mm		H:RCD, mm:mm	No of buds		WADC, g				
								shoot		roots		ratio
	X	SD	X	SD		X	SD	X	SD	X	SD	
BR	74.9	1.20	2.53	0.39	32	3.6	1.2	–		–		–
PP	97.7*	1.63	2.22*	0.49	44	1.6	1.5	0.47	0.12	0.25	0.09	1.88
YS	75.2	1.18	2.11*	0.28	36	3.2	1.0	0.42	0.11	0.25	0.10	1.68
PS	84.5	1.79	2.13*	0.30	40	3.6	1.4	0.58	0.13	0.38	0.13	1.53

Table 2. Biometrical features of the trees of "Pirosad" seedlings origin.

Exp. field	Alti-tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\,m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	11	36.8	10.0	9.2	0.8	0.2	0.2	-	-	2
B	500	4	30	39.7	6.9	9.9	0.9	0.2	0.2	-	-	2

of 4-year-old trees is 34.4 cm, while 14-year-old trees reach 323.2 cm. RCD increases from 0.8 cm to 10.8 cm by 4, resp. 14-year-old trees. The AHI varies from 8.6 cm to 26.8 cm, and the ADI from 0.2 cm to 0.9 cm.

2.3. "Yucosad"

Trees in 5 stands and 4 experimental fields, 4–17 years of age, were analyzed (Table 4). The shoot height varies from 27.9 cm (4-year-old trees) to 402.9 cm (17-year-old). RCD increases from 0.6 cm to 11.5 cm (4, respectively 17-year-old trees). The AHI varies from 7.0 cm to 25.6 cm and the ADI 0.2 cm to 1.0 cm.

2.4. "Bare root"

Trees in 3 stands and 4 experimental fields 4–19 years of age, were investi-

Table 3. Biometrical features of the trees of "Paperpot" seedlings origin.

Exp. field	Alti–tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\,m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	30	34.4	7.9	8.6	0.8	0.1	0.2	–	–	1
B	500	4	30	44.6	9.5	11.2	0.9	0.2	0.2	–	–	1
	400	5	30	49.9	12.8	10.0	1.3	0.4	0.3	–	–	2
	325	10	20	132.2	14.3	13.2	6.2	0.9	0.6	–	–	2
C	1300	10	20	206.7	34.6	20.6	7.8	1.6	0.8	3.5	2.2	3
D	450	11	20	277.9	46.4	25.3	9.5	1.7	0.9	4.4	1.3	3
	300	12	30	204.6	42.2	17.1	6.6	0.8	0.5	1.9	0.5	2
	630	13	17	205.8	29.0	15.8	7.9	1.0	0.6	2.9	1.0	2
	615	13	19	258.6	32.3	19.9	8.0	1.1	0.6	3.7	0.7	2
	600	13	17	348.5	38.4	26.8	10.4	1.6	0.8	6.0	0.8	3
	300	14	20	323.2	29.5	23.1	10.8	1.8	0.8	6.7	1.0	3

Table 4. Biometrical features of the trees of "Yucosad" seedlings origin.

Exp. field	Alti-tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\,m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	11	34.5	7.9	8.6	0.8	0.1	0.2	-	-	1
B	500	4	30	34.7	6.9	8.6	0.8	0.0	0.2	-	-	1
	400	4	20	27.9	6.4	7.0	0.6	0.2	0.2	-	-	2
	400	5	30	55.0	12.2	11.0	1.4	0.3	0.3	-	-	2
	700	8	30	146.1	17.0	18.3	7.7	1.2	1.0	1.8	0.4	2
C	1300	10	20	230.6	37.0	23.1	9.0	1.6	0.9	3.9	1.2	3
D	450	11	17	281.1	42.2	25.6	9.8	1.3	0.9	4.7	1.2	3
	300	16	30	351.7	33.3	22.0	11.3	1.1	0.7	7.0	0.9	3
	420	17	29	402.9	40.7	23.7	11.5	1.4	0.7	7.3	1.0	3

gated (Table 5). The shoot height varies from 38.3 cm (4-year-old trees) to 428.6 cm (19-year-old). RCD increases from 0.8 cm to 12.8 cm by 4, resp. 19-year-old trees. The AHI varies from 7.7 cm to 23.1 cm, and the ADI from 0.2 cm to 0.9 cm.

2.5. Experimental fields

Four of the investigated stands were established as experimental fields A, B, C and D. In Tables 6–9 a repetition of the features of trees from the experimental fields (from Tables 2–5) is presented, separately

Table 5. Biometrical features of the trees of "Bare root" seedlings origin.

Exp. field	Alti-tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\,m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	11	42.7	9.3	8.5	0.8	0.2	0.2	–	–	1
B	500	4	30	38.3	8.7	7.7	0.8	0.3	0.2	–	–	1
	1000	9	30	121.8	26.9	13.5	6.2	1.4	0.7	–	–	2
C	1300	10	17	249.3	46.8	22.7	9.6	2.1	0.9	4.5	1.6	2
D	450	11	18	277.1	40.8	23.1	9.6	1.5	0.8	4.5	1.3	3
	420	17	30	317.0	27.1	18.6	12.5	1.7	0.7	6.5	1.0	3
	380	19	30	428.6	48.5	22.6	12.8	1.8	0.7	7.9	1.3	3

Table 6. Biometrical features of the trees in experimental field A.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survival %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
A	BR	4	30	38.3	8.7	7.7	0.8	0.3	0.2	–	–	1	20
A	PS	4	30	39.7	6.9	9.9	0.9*	0.2	0.2	–	–	2	40
A	PP	4	30	44.6*	9.5	11.2	0.9*	0.2	0.2	–	–	1	30
A	YS	4	30	34.7	6.9	8.6	0.8	0.0	0.2	–	–	1	30

for each experimental field, together with the results of comparative analyses of statistical testing (with BR trees as control).

Experimental field A (Table 6) represents a young stand, where ecological conditions are far from favorable for Austrian black pine (250 m a.s.l.) Best results show PP and PS trees, while YS trees have worst features. PP seedlings are statistically higher and thicker than control (BR). Vitality of all seedling types is poor to medium, and survival range is low.

Quite similar situation is recorded in experimental field B (Table 7), which also represents young stand in less favorable ecological conditions (500 m a.s.l.) Best results manifest BR trees, while container stock types have quite similar features. Vitality of all seedling types is poor to medium. Survival range is low in all seedling types.

Experimental field C (Table 8) is raised in very favorable ecological conditions (1300 m a.s.l.) BR trees have statistically better features compared to trees with container origin. Vitality of all trees is good. Survival range is high in all seedling types.

Experimental field D (Table 9) is raised in less favorable ecological conditions (450 m a.s.l.), however vitality of all trees is good and survival range is high. Features of trees of all seedlings stock types are very close, without statistically significant differences.

From this investigation arises that container type, i.e. its volume, does not directly influence the seedlings quality. Quite big differences between container vol-

Table 7. Biometrical features of the trees in experimental field B.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survival %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
B	BR	4	11	42.7	9.3	8.5	0.8	0.2	0.2	–	–	1	20
B	PS	4	11	36.8	10.0	9.2	0.8	0.2	0.2	–	–	2	40
B	PP	4	30	34.4*	7.9	8.6	0.8	0.1	0.2	–	–	1	30
B	YS	4	11	34.5*	7.9	8.6	0.8	0.1	0.2	–	–	1	30

Table 8. Biometrical features of the trees in experimental field C.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survival %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
C	BR	10	17	249.3	46.8	22.7	9.6	2.1	0.9	4.5	1.6	3	80
C	PP	10	20	206.7*	34.6	20.6	7.8*	1.6	0.8	3.5*	2.2	3	90
C	YS	10	20	230.6*	37.0	23.1	9.0	1.6	0.9	3.9*	1.2	3	85

Table 9. Biometrical features of the trees in experimental field D.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survival %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
D	BR	11	18	277.1	40.8	23.1	9.6	1.5	0.8	4.5	1.3	3	90
D	PP	11	20	277.9	46.4	25.3	9.5	1.7	0.9	4.4	1.3	3	95
D	YS	11	17	281.1	42.2	25.6	9.8	1.3	0.9	4.7	1.2	3	95

ume (70, 120 resp. 160 cm^3) are not followed by respective differences in seedling features (PP seedlings from 120 cm^3 are statistically higher than PS seedlings from 160 cm^3 volume container). Many researchers, who investigated seedling development in various containers, have come to similar conclusions (Petrovic 1991, Lokvenc 1980, Popovski 1986). However, more important than initial seedlings features is their survival and growth on new site. Investigations on stands established with container seedlings have been executed worldwide (Thompson 2001, Van Eerden and Arnott 1974, Jones et al. 2002, Scarrath 1991), which testify about great importance of this issue. Volná and Mauer 1983, Stilinovic et al. 1980, Lokvenc 1985, Šmit et al. 1985, Kolevska 1995, etc. established that development of trees depends on number of factors, and among them container type has various influence. However, vitality and development of trees from container seedlings reflect their complex condition, specially their non-visible part – the root system (according to Lokvenc, 1980, 1985, Volná and Mauer (1983) etc.) They established that one of the factors which can significantly influence the development of the "container stands" is roots deformations, which emerge during the growth of seedlings in the container and/or during and after transplantation.

Comparison of features of young trees (age 4–5 years) in this investigation, with the results of Austrian black pine stands investigations at the same age, container types and similar ecological conditions (Popovski et al. 1983, Stilinovic et al. 1986, Kitic and Vilotic 1985 etc.) does not show considerable differences. Most of other investigators emphasize on the mutual influence of site factors and planting procedures on the future development of stands, and they do not consider container type as a crucial factor. Survival and development of young container trees depends more on site conditions and planting techniques, because of relatively small dimension of the shoot and root ball (possible damages of weeds, danger of drought, root deformities). Especially dry sites, unfavorable soil conditions, poor site preparation and bad planting can cause serious problems in stand development. In such conditions, regeneration of roots is poor, which causes worse seedlings survival and vitality. This is the case in our investigation, where all young stands, raised on dry sites, manifest poor vitality and survival (20–40 %) and numerous root deformities. Even the Pirosad seedlings with the biggest volume of the container have quite a low survival range (ca. 35 %). This proves that even container seedlings can face a biological shock after transplanting, similarly to bare root seedlings.

According to this investigation, the influence of container type on development of trees in older stands becomes even less significant. All analyzed stands develop more or less normally, conditionally to planting techniques and site conditions. Vitality of older stands is medium to good, and there is no crucial influence of specific container type recorded. The experimental fields confirm such statement: bigger differences between trees of different origin were recorded on experimental field C, while very small ones on field D.

Conclusions

Best parameters have “Pirosad” and “Paperpot” seedlings. The other seedling stock types have satisfactory quality parameters.

Growth and vitality of trees, raised from different seedling types, by various planting techniques and developing in different ecological conditions, do not depend primarily on seedling type.

Young container stands have faced biological shock similarly to bare root seedlings. Development of stands is influenced mostly by climatic conditions in the first years after transplanting, site conditions, quality of planting, etc. Older stands, raised both from container and bare root seedlings, develop well.

All investigated container type seedlings, i.e. “Paperpot”, “Yucosad” or “Pirosad”, with a prerequisite of expert, consistent, timely and high-quality executing of all separate steps in seedling production and planting process will contribute to development of productive, stable and healthy stands.

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SEED DORMANCY BREAKING OF WILD CHERRY (*PRUNUS AVIUM* L.)

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Abstract

Several methods for overcoming wild cherry seed dormancy have been studied. Wild cherry (*Prunus avium* L.) seeds have shown to be affected by combined dormancy: weak morphological and deep physiological dormancy. Fresh stones responded differently to the various methods for dormancy breaking. The study showed that the dormancy of fresh seeds is successfully overcome by sowing the seeds immediately after their harvest or in autumn. Stored seeds, however, did not have a positive response to these specific sowing periods. Acceptable germination rates were achieved after application of seed stratification. Findings showed that accelerated stratifications did not give positive results for successful dormancy break in the conditions of Bulgaria. Stored seeds should be sown in spring after application of combined warm and cold stratifications with the following durations: 6 weeks of warm period and 5 months of cold period.

Key words: germination, seed dormancy breaking, stratification, wild cherry.

Introduction

Seeds of wild cherry (*Prunus avium* L.) often do not possess satisfactory germination. It depends on the conditions during the year, the individual genetic differences and the embryo dormancy. This requires selecting a suitable sowing period and appropriate stratification (Michev 1953; Dirr and Heuser 1987; Suszka et al. 1996; Eşen et al. 2006, 2009).

Previous and some recent studies accepted that the stone endocarp caused the mechanical dormancy of seeds (Tukey 1924, Hartmann and Kester 1983, 2002; Çetinbaş and Koyuncu 2006). Different methods for its removal have been applied most often without positive results (Zielinski 1958). Later, Suszka et al. (1996) rejected the possibility of its role in germination delay.

It has been thought for many years that dormancy breaking requires cold stratification at temperatures from 1.7 °C to 6 °C (Crocker 1931, Giersbach and Crocker 1932, Coe and Gerber 1934, Haut 1938, Zielinski 1958, Huntzinger 1968, Seeley and Damavandy 1985).

Suszka (1967) proved that germination is significantly improved by alternating warm and cold stratifications: 14 days at temperature of 20 °C followed by 189 days at 3 °C. Similar approach was adopted by Dirr and Heuser (1987): 3–6 weeks of stratification at temperature of 15–21 °C followed by cold stratification at 4–5 °C for 12–21 weeks.

Suszka (1967) proposed a new method of stratification involving alternating treatments: initial period at temperature 25 °C followed by a cold period for two weeks at 3 °C and a subsequent period again at temperature of 25 °C (Table 1, test variant 1).

Later, some researchers also used pre-sowing preparatory treatments of alternating warm and cold phases. Muller et al. (1990) proposed 3 cycles of warm and cold stratification. Table 1 shows few more recommended approaches: Michalska and Suszka (1980a, 1980b) – test variant 2; Seeley and Damavandy (1985), Eşen et al. (2009) – test variant 3; Suszka et al. (1996) – test variants 4, 5, 6.

When the cold period is not long enough and is interrupted by a warm one, secondary dormancy is induced (John et al. 2003). This results in the epicotyl losing its ability to grow, the formation of a shortened shoot and leaf rosette, and a delay in the growth of rootlets (Suszka 1967, Huntzinger 1971, Michalska 1982).

Seeds may be sown immediately after harvest in July or August (Dirr and Heuser 1987, Suszka et al. 1996), or earlier in autumn, from the beginning of September to mid-October at the latest (Swingle 1925, Huntzinger 1971, Grisez 1974, Grzeskowiak et al. 1983). If the stones are stratified in a controlled environment, sowing may take place immediately before winter (Suszka et al. 1996).

Although the technology for seedling production is considered to be well-established, there are still unclear points concerning the organic dormancy and the ways for overcoming, which was proved by numerous varied recommendations for different pre-sowing treatments and periods of sowing. The reason is the regional nature of the studied biological traits. Presented issues outline the need for studies aiming to clarify the specificity of dormancy of native populations and the ways for overcoming it.

Material and Methods

Seeds from 6 sources were used in this study (Fig. 1):

Table 1. Test variants of pre-sowing treatments of wild cherry seeds.

Variant	Sequence/duration of stratification phases (weeks)											
	warm		cold		warm		cold		warm		Cold	
1	2 w	25 °C	2 w	3 °C	2 w	25 °C	12–16 w	3 °C	–		–	
2	2 w	20 °C	8 w	3 °C	2 w	25 °C	3 °C to the end		–		–	
3	2 w	20 °C	6 w	3 °C	2 w	25 °C	4 w	3 °C	2 w	25 °C	11 w	3 °C
4	–		6 w	3 °C	2 w	25 °C	2 w	3 °C	2 w	25 °C	12–16 w	3 °C
5	2 w	20 °C	6 w	3 °C	2 w	25 °C	2 w	3 °C	2 w	20–25 °C	8–12 w	3 °C
6	2 w	20–25 °C	2 w	3 °C	2 w	20–25 °C	12–16 w	3 °C	–		–	

Forest Service Targovishte – seed lots No 1, 2 (plot 13 и 187);

Forest Service Smyadovo – seed lots No 3, 4 (plot 156);

Forest Service Sofia – seed lot No 5 (plot 382);

Forest Service Gabrovo – seed lot No 6 (plot 257);

Forest Service Belovo – seed lot No 7 (plot 610);

Forest Service Cherni Lom – seed lot No 8 (plot 67).

The seeds were collected in 2006.

The seed viability has been assessed according to ISTA 1996.

The effect of sowing periods and various pre-sowing treatments on fresh and stored-for-one-year seeds has been studied to evaluate their germination in soil on the basis of the following test variants:

Variant 1 – Control: viability testing;

Variant 2 – Summer sowing in the field;

Variant 3 – Autumn sowing of stored seeds in the field;

Variant 4 – 4 months of cold stratification (according to ISTA 1996);

Variant 5 – Stratification: 3-months warm phase + 4-months cold phase;

Variant 6 – Stratification: 6-weeks warm phase + 5-months cold phase;

Variant 7 – Accelerated stratification: 6-weeks cold phase, 2-weeks warm phase, 2-weeks cold phase, 2-weeks warm phase, 12 to 16-weeks cold phase;

Variant 8 – Accelerated stratification: 2-weeks warm phase; 2-weeks cold phase, 2-weeks warm phase, 2-weeks

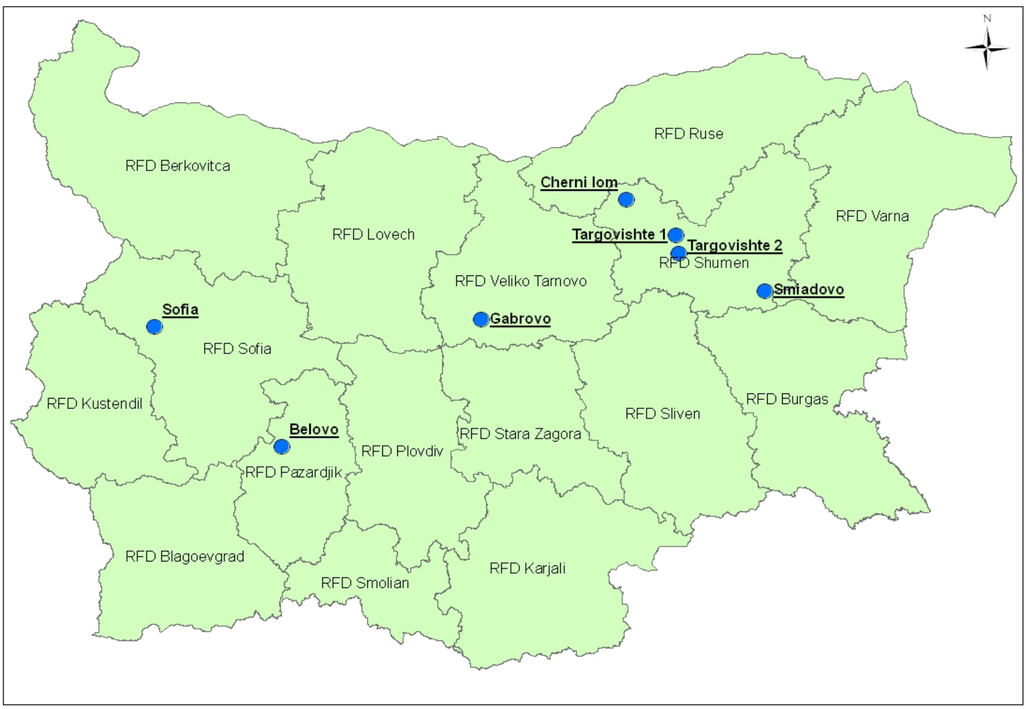

Fig. 1. Map of Bulgaria with the sources of seeds used in the experimental work.

cold phase, 2-weeks warm phase, 8-weeks cold phase.

The medium used for the pre-sowing treatments was perlite. Sowing took place in a greenhouse at temperature of 20–25 °C.

Results were statistically analyzed using SPSS software, ANOVA and Post Hoc Test and a confidence level at 95 %. To show the statistical differences of the results, the test variants without statistically significant differences were indicated with the same capital letter, while those with statistically significant differences – with a different letter.

Results and Discussion

The seed viability (Table 2) varied from 80 % (Sofia) to 98 % (Smyadovo). After one year of storage it decreased by between 1 and 5 % depending on the seed lot.

The seed germination is shown in Table 2. Fresh seeds had the highest germination in the summer and autumn sowing test variants (62 % on average). Values for each seed lot vary from 51 % (Sofia) to 73 % (Targovishte) for the summer sowing test variant, and from 42 % (Belovo) to 78 % (Targovishte) for the autumn sowing one.

Table 2. Seed viability.

No	Seed lot	Variant 1	Variant 2		Variant 3		Variant 4		Variant 5		Variant 6		Variant 7		Variant 8	
		Seed viability, %	M±SE	V, %	M±SE	V, %	M±SE	V, %	M±SE	V, %	M±SE	V, %	M±SE	V, %	M±SE	V, %
1	Targovishte 1	88	56±3	32.9	61±4	57.7	6±0.3	0.3	5±1	1.7	16±2	13.3	1±0.3	0.3	10±2	17.7
2	Targovishte 1s	93	–	–	7±1	8.7	5±3	25.7	19±6	126.2	82±3	30.2	2±1	8.2	5±3	27
3	Targovishte 2	97	73±3	44.7	78±4	76	9±2	24.9	10±3	24.9	47±6	165.7	1±0.5	0.9	31±4	65.6
4	Targovishte 2s	97	–	–	2±2	14.9	21±2	22.9	79±2	10.9	49±10	375.6	0	0	0	0
5	Smyadovo 1	98	59±7	208.2	71±2	12.2	13±3	41	11±3	30.3	16±2	10.9	2±1	8	36±3	32.9
6	Smyadovo 1s	31	–	–	0	0	0	0	0	0	10±0.5	0.9	0	0	0	0
7	Smyadovo 2	98	58±8	235	68±3	30.9	12±4	49.3	13±2	14.9	16±2	9.6	2±1	4.7	20±6	127
8	Smyadovo 2s	96	–	–	1±1	2	34±3	25.6	77±1	6.7	82±5	117.6	1±1	1	0	0
9	Belovo	95	67±6	157.3	42±1	4.9	5±1	6.7	4±0.4	0.7	8±1	5.7	1±05	0.9	11±3	30
10	Belovo – s	93	–	–	22±2	13.3	16±2	21.6	72±5	88.7	73±5	86.7	4±2	12.3	6±2	18.9
11	Sofia	80	51±5	106.9	49±0.5	0.9	9±0.3	0.3	2±0.4	0.7	12±3	34.7	2±1	1.7	12±1	5.67
12	Sofia – s	75	–	–	14±3	37.6	24±3	34.9	66±7	199	71±6	140.7	2±1	6.9	4±2	18.9
13	Gabrovo	97	63±3	39.6	61±1	4.3	18±1	2.7	5±2	13.3	15±3	43.3	3±1	3.3	21±1	4.3
14	Gabrovo – s	96	–	–	1±0.3	0.3	3±1	1.7	84±2	14	82±6	155.3	3±1	5.7	0	0
15	Cherni Lom	98	72±4	55.3	63±2	24.9	17±2	13.3	18±1	7	10±5	87	2±1	1.7	11±2	12.2
16	Cherni Lom – s	97	–	–	1±1	2	29±3	48.2	32±7	211.6	72±5	116.3	1±1	2.2	0	0

Note: Used symbols have following meaning:
1. letter “s” is used to indicate stored seeds of various seed lots.
2. “M” – mean values; “SE” – Standard error; “V, %” – coefficient of variation.

The autumn sowing test variant showed the same or higher germination percentage compared to that of the summer sowing. This indicates that the morphological dormancy was not too pronounced, and the period of seed dormancy was taking place at the higher temperatures in autumn before the winter cold was enough for the dormancy break.

The cold stratification for 4 months resulted in low germination: 11 % on average, from 5 % (Belovo) to 18 % (Gabrovo). This is an indicator of morphological dormancy, which requires a warm phase.

The test variants of warm and cold stratification, however, did not have the expected high germination percentage of the fresh seeds. Test variant 5 had an average value of 8 %: from 2 % (Sofia) to 18 % (Cherni Lom). Test variant 6 resulted in an average germination of 17 %, varying from 8 % (Belovo) to 47 % (Targovishte). These results indicate that wild cherry seeds do possess combined morpho-physiological dormancy. It can be accepted that a warm phase for 6 weeks is a long enough period. At the same time, a 4-month-long cold period was not long enough to overcome the physiological dormancy and better results were obtained when the cold phase lasts for at least 5 months.

The alternation of short, warm and cold phases (test variant 7) probably led to the induction of secondary seed dormancy. The low germination indicates that when there is morphological dormancy, it is not justified to begin the pre-sowing treatment with a cold phase.

Having a warm phase for a period of 2 weeks at the start and increasing the number of treatments (test variant 8) resulted in increase in germination from 2 % to 19% (from 11 % for Belovo and Cherni Lom to 36 % for Smyadovo 1).

Stored seeds showed different tendencies in comparison with fresh seeds. Seeds from all seed lots did not germinate in the summer sowing test (Table 2). The autumn sowing also showed very low values: an average of 6 %, from 1 % (Smyadovo 2, Gabrovo and Cherni Lom) to 22 % (Belovo).

In general, common warm and cold stratifications have shown considerably better results in comparison with the accelerated pre-sowing treatments.

The stored seeds' germination was most intensive with the warm and cold stratification (test variant 6) – on average 61 %, from 49 % (Targovishte 2) to 82 % (Gabrovo, Smyadovo 2 and Targovishte 1). An exception with a low germination percentage is the seed lot of Smyadovo 1.

Test variant 5 had an average germination percentage of 54 %. The germination percentage of the seed lots ranged from 19 % (Targovishte) to 84 % (Gabrovo).

Accelerated stratifications had a seed germination of less than 10 %. Considering the fact that the 4-months-long cold stratification led to an average germination of 16 % (from 3 % for Gabrovo to 34 % for Smyadovo 2), it can be concluded that these accelerated stratifications induced secondary physiological dormancy in the stored seeds as well.

Table 3 shows the significance of various factors on seed germination. Of the three tested factors, type of stratification/sowing period and seed lot quality significantly affected the seed germination.

Of the two factors, a stronger effect on seed germination had the type of stratification (92 % in the fresh seeds, and 77 % in the stored seeds). The seed lot quality had a considerably less profound effect: 7 % in the fresh seeds and 22 % in the stored seeds, respectively. A factor without statistical significance was the type of seeds. This means that regardless of whether the seeds are fresh or stored, selecting the right approach for dormancy breaking, i.e. type of stratification or sowing period, ensures high soil germination.

Table 3. Effect of various factors on seed germination (ANOVA test).

Factor	Degrees of freedom	Level of significance (p-value)
Type of stratification	7	0.000
Seed lot	7	0.000
Type of seeds (stored/fresh)	1	0.395
Type of stratification * seed lot	49	0.000
Type of stratification * Type of seeds	7	0.000
Seed lot * Type of seeds	7	0.000
Type of stratification * Type of seeds * Seed lot	42	0.000

Tables 4 and 5 show the significance of the different factors affecting seed germination.

Considering the method applied for overcoming the organic dormancy in the process of seed germination, it has been found out that summer and autumn sowing of the fresh seeds led to statistically insignificant results: 62 %.

Statistically insignificant results were also obtained for the stored seeds from the stratification test variants 4 and 5: from 11 % to 8 %. These results show that the period of 4 months is not long enough cold phase.

Statistically, test variants 6 and 7 can be regarded as insignificant: their germinated seeds were 17 % and 19 %, respectively.

Test variant 7 had the lowest germination of 2 % which is statistically significant in comparison to all other test variants. Therefore, in order to overcome the morphophysiological dormancy, it is not appropriate to begin the pre-sowing treatment with a cold phase.

For the stored seeds, only the two test variants of accelerated stratification had statistically insignificant results: germination of 2 %. All other test variants show values which have statistically significant differences.

The highest germination of 61% was obtained with the warm and cold stratification of test variant 6.

Table 4. Effect of type of stratification on seed germination, %.

Type of stratification	Fresh seeds		Stored seeds	
	M±SE	V, %	M±SE	V, %
Seed viability	94±1 a	38.6	85 ±4 a	47.4
Summer sowing	62±2 b	140.8	–	–
Autumn sowing	62±2 b	140.2	6±1 b	65.4
Variant 4	11±1 c	34.9	16±2 c	165.9
Variant 5	8±1 c	34.2	54±6 d	986.6
Variant 6	17±2 d	171.2	61±5 e	738.8
Variant 7	2±0 e	2.7	1±0 f	5.2
Variant 8	19±2 d	119.3	2±0 f	12.1

Table 5. Effect of seed lot quality on seed germination, %.

Type of stratification	Fresh seeds		Stored seeds	
	M±SE	V, %	M±SE	V, %
Seed viability	94±1 a	38.6	85 ±4 a	47.4
Summer sowing	62±2 b	140.8	–	–
Autumn sowing	62±2 b	140.2	6±1 b	65.4
Variant 4	11±1 c	34.9	16±2 c	165.9
Variant 5	8±1 c	34.2	54±6 d	986.6
Variant 6	17±2 d	171.2	61±5 e	738.8
Variant 7	2±0 e	2.7	1±0 f	5.2
Variant 8	19±2 d	119.3	2±0 f	12.1

The summer and autumn sowing of fresh seeds (Table 4) led to the same results with regard to germination as did the application of the warm and cold stratification for the stored seeds: germination of 62 % and 61 %, respectively.

Table 5 shows the effect of seed lot quality on seed germination. Used seed lots were not uniform, and they showed different physiological response to the various treatments. These may be grouped as follows: the first group with the highest average germination of 43 % includes seed lot Targovishte 2. The second group includes seed lot Smyadovo 1 (38 %). The third group consists of the following seed lots: Smyadovo 2, Gabrovo, Belovo and Popovo with an average germination ranging between 29 % and 36 %. The seed lots of low quality seeds are Sofia and Targovishte 1 with an average germination ranging between 27 % and 30 %.

After storing the seeds for one year, their germination decreased with statistical significance by 2 % on average, from 34±2 % for fresh seeds to 32±2 % for stored seeds.

Conclusion

Wild cherry seeds possess combined dormancy: relatively weak morphological and deep physiological dormancy.

The storage of seeds until maturity at the beginning of September following the rules for storing dry seeds does not intensify their typical organic dormancy.

Fresh and stored seeds respond differently to the various approaches for overcoming their organic dormancy. Stratification of fresh seeds does not successfully overcome dormancy. The best approach for them is to be sown in summer, immediately after being harvested, or at the beginning of September.

Stored seeds do not have a positive response to specific periods of sowing, whether in summer or autumn. Good germination for them can be expected after applying a pre-sowing treatment. The accelerated combined stratifications do not realize the seeds' biological germination potential in the conditions of Bulgaria. Stored-for-one-year seeds should be sown in spring after warm and cold stratification involving a 6-week-long warm phase and a 5-month-long cold phase.

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INTERPRETATION OF THE MAP OF THE EROSION IN THE CATCHMENT AREA OF ZHELYAVSKA RIVER TORRENT

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Abstract

The map of erosion has been drawn on the basis of black-and-white aerial photographs. Seven categories of terrain were differentiated according to land cover type and the areas subjected to erosion. Map interpretation included an analysis of the impact of the main relief characteristics (inclination, altitude and exposure) together with human activity upon the state of the studied terrains. This state was judged by the index of erosion. The impact of inclination has been found to be multi-aspect, depending on exposure. The latter, compared with the rest of the relief characteristics, predetermined erosion to the greatest extent. We confirmed the decisive impact of anthropogenic activity.

Key words: erosion, mapping, interpretation, and index of erosion.

Introduction

The watershed is situated on the southern inclination of the Balkan Mountain, in the vicinity of Sofia. The object of this study is its upper portion at 756–1295 m altitude. The region is characterized by moderately heavy erosive rainfalls. The annual sum of precipitation is 650–750 mm (Onchev 1983). The maximum amount of precipitation per 24 hours is 70–80 mm. The bedrock is composed of clayey schists. The watershed area amounts to 907 ha. According to land-cover types, it is distributed into:

– Forests – 551.2 ha (60.8 %);
– Clearings – 154.8 ha (17.1 %);
– Barrens – 201.0 ha (22.1 %).

Almost all forests (95 %) are natural. The most common formations are composed of Oriental hornbeam (*Carpinus orientalis* Mill.) and European hornbeam (*Carpinus betulus* L.). These have appeared secondarily, at the places of destroyed oaks (*Quercus* sp.) and Common beech (*Fagus sylvatica* L.) forests (Bondev and Lyubenov 1983). The artificial forests are mainly of Austrian pine (*Pinus nigra* Arn.). As an average, the forests are about 60 years of age.

In 1935, the village of Zhelyava had 1,188 residents, whose livelihood was related to a great extent to animal production. In 2008, the residents diminished down to 449 people, the largest proportion of whom are retired.

The purpose of the present study is to draw a map of erosion using aerial photographs and to interpret this map. In order to achieve the goal, two main tasks were implemented:

– Differentiation, characterization and categorization of the polygons;

Investigation of the impact of relief and anthropogenic activity.

Literature Review

The initial information about the regions of prevailing levels of erosion for the whole territory of this country has been presented as a scheme-based map (Biolchev et al. 1959). On it, two characteristics were reported: inclination and plant cover.

In the recent three decades, mapping has been based on remote-sensing methods, such as aerial photogrammetry. The main diagnostic features have been land-cover type, vegetation cover, and soil erosion (Zakov 1994, 2003, 2005).

Satellite images and geographic information systems (GIS) have also been used for mapping the risk of erosion. The potential risk of erosion was determined on the basis of the maps of inclination, potentially hazardous rainfalls, and the vulnerability of soils to erosion. Plant cover was additionally taken into account for determining the real risk of erosion (Stoev et al. 1997, Malinov at al. 1998, Mårtensson et al. 2001).

For practical needs, the erosion maps must contain information about the eroded areas. Aerial photographs can be used as sources of such information about torrential watersheds of small areas.

Method of Study

Remote sensing of erosion on the basis of aerial photographs is a process of studying homogenous parts of the land surface with different levels of erosion, called further on “polygons” delineated on their photographic images. The present study has been carried out by means of black-and-white aerial photographs in an approximate scale of 1: 15,000 at four stages:

Preliminary study:
– Introduction into the situation;
– Studying the factors of erosion;

Collecting information:
– Mapping the erosion;
– Characterizing the polygons;

Processing the information:
– Categorizing the polygons;
– Categorizing the terrains;

Evaluating the results:
– Verifying the results;
– Interpreting the map of erosion.

The “introduction into the situation” is provided by stereoscopic observation of the watershead, as it visualizes the specificity of each of its different parts. The study of the conditions that determine erosion hazard reveals the reasons for the diversity of the photographic images.

Initially different inclinations of the relief are delineated on of the photographic images, forming large parcels. In each of these parcels polygons are delineated, each of which corresponds to one of the 3 types of land cover: forests, clearings and barrens. The minimum polygon area is 1.0 ha. The characteristics of each polygon are its area, altitude, inclination, exposure, plant cover (of trees and grasses) and the level of erosion. The percentage of each area covered with tree and grassy vegetation and/or subjected to erosion was determined through photogrammetric methods by means of a transparent plastic sheet with a regular dot-grid.

Polygons are categorized according to two features: land-cover type and erosion level. According to the first one, they are subdivided into forests (I), clearings (II) and barrens (III). On the basis of the ratio of the number of dots falling on erosion-subjected areas to the total number of dots in a polygon or in a representative part of it the following levels of erosion have been differentiated, expressed in percentage as follows:

Slight erosion (a) – up to 10 %;

Moderate erosion (b) – 11 % – 30 %;

Severe erosion (c) – 31 % – 50 %;

Very severe erosion – over 50 %.

Slightly eroded terrains are considered protected against erosion. The first three levels of erosion are found both in the forests and in the clearings, whereas the fourth one - only in the barrens. On the basis of the land cover type and the level of erosion, the delineated polygons have been assigned to the following terrain categories:

Ia (forests with slight erosion) – 293.1 ha (32.3 %);

Ib (forests with moderate erosion) – 161.6 ha (17.8 %);

Ic (forests with severe erosion) – 96.5 ha (10.6 %);

IIa (clearings with slight erosion) – 96.5 ha (10.6 %);

IIb (clearings with moderate erosion) – 16.9 ha (1.9 %);

IIc (clearings with severe erosion) – 41.4 ha (4.6 %);

III (barrens with very severe erosion) – 201.0 ha (22.2 %).

Because of its limited area, Ib category has been united with IIa category.

After careful verification, the final categorization of the polygons has been completed, and the map of erosion has been finalized.

The ratio of the area of the terrains with severe and very severe levels of erosion to the total area of parts that are homogenous features to a particular topographic characteristic class defines the erosion index (E). The following scale has been adopted for determining erosion condition of polygons:

– very bad – $E > 0.5$;
– bad – $0.3 < E < 0.5$;
– good – $0.1 < E < 0.3$;
– very good – $E < 0.1$.

Interpreting of the Erosion Map

Within the studied watershead 161 polygons are differentiated. Interpreting the map of erosion is directed to the analysis of the joint impact of the relief and the human activity.

Inclination. For studying the impact of inclination, terrains have been distributed into five classes:

I_{I} – (up to 25 %) – oblique – 99.4 ha (11.0 %);

I_{II} – (30 and 35 %) – steep – 83.0 ha (9.2 %);

I_{III} – (40 and 45 %) – very steep – 186.9 ha (20.6 %);

I_{IV} – (50 and 55 %) – abrupt – 227.8 ha (30.6 %);

I_{V} – (60 and 65 %) – sheer – 259.9 ha (28.6 %).

The distribution of the area of each class according to terrain categories (in the numerator) and of each category according to inclination classes (in the denominator) is presented in Table 1.

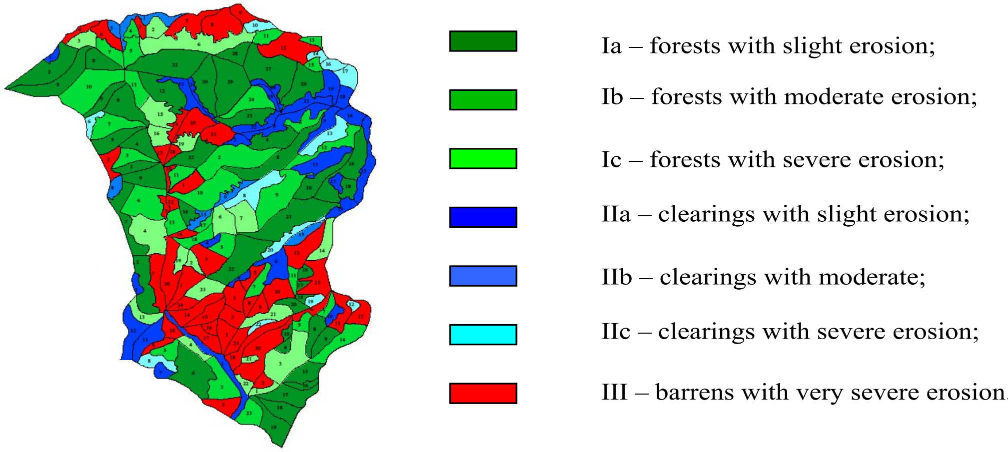

Fig. 1. Map of erosion.

Inclination Class Characteristics

The inclination of I_I class are occupied mainly by clearings, and 94.3 % of these are protected against erosion. The unavailability of forests is a consequence of their destruction of the latter for the purpose of creating highly productive pastures. There are no barrens in this class, which means that on inclinations of up to 25 % the grassy cover successfully regulates the runoff.

In the next class, a drastic aggravation of the situation is observed; it is expressed in the appearance of barrens (18.6 %) and in the multiple increase in the proportion of clearings with severe erosion (34.3 %). The availability of forests (18.2 %) and clearings (22.4 %) protected against erosion is due mainly to their preservation as property of the Bulgarian Orthodox Church.

As inclination increases to 40–50 %, the state of the terrains aggravates even more. With a few exceptions, the clearings have been turned into barrens, which occupy over half (55.0 %) of the area. The

Table 1. The influense of inclination upon the distribution of areas.

Inclination class	Total area of the terrain categories, ha/%						Index of erosion
	Ia	Ib	Ic	IIa	IIc	III	
I_{I}	–	–	–	94.3/81.4	5.7/13.5	-	0.06
I_{II}	18.2/5.4	3.6/1.9	2.9/2.6	22.4/17.0	34.3/71.5	18.6/8.0	0.56
I_{III}	11.0/7.0	15.7/18	13.9/26.6	1.0/1.6	3.3/15.0	55.0/50.6	0.72
I_{IV}	47.4/44.9	25.0/43	16.7/48.1	–	–	10.9/15.1	0.28
I_{V}	48.2/42.7	23.1/37.1	8.4/22.7	–	–	20.3/26.3	0.29

proportion of the forests with severe erosion increases up to 13.9 %.

The situation with the last two classes shows a significant improvement: almost half of the forests are protected against erosion. Together with the forests of moderate level of erosion, they occupy over 70 % of the area. However, in these classes, also relatively high percentage of barrens is preserved: 10 % – 20 %.

The values of the erosion index are an indicator for switching trends in the condition of the terrains, parallel with the increase of inclination. These values increase from 0.06, in the I_I class, to over 0.50, in the I_{II} and the I_{III} classes, and then they decrease to lower than 0.30, in the I_{IV} and I_V classes. Based on them, the state of the terrains has been determined as:

– I_I class – very good;
– I_{II} and I_{III} classes – very bad;
– I_{IV} and I_V classes – good.

Characteristics of the categories

The results in Table 1 show that the forests are best represented in the I_{IV} class, where they occupy about 45 % of the category area. In the following, I_V, class, the shares of Ia и Ib Categories do not change substantially, but the share of Ic category decreases to 22.7 %. In the previous, I_{III} class, the smallest proportion belongs to the forests protected against erosion (7.0 %), and the largest one – to the forests with severe erosion (26.6 %). This is due mainly to the stronger anthropogenic impact upon the forests on less steep inclinations: they have easier to access for logging and pasture. In a lot of cases, the state of the terrains in Ic category has been influenced by the water runoff from the clearings and barrens on the higher parts of the inclinations.

In the clearings, there is a well-expressed trend toward an aggravation of their state as inclination increases. The clearings with severe erosion prevail in the I_{II} class (71.5 %), whereas those protected against erosion are best represented in I_I class (81.4 %).

The distribution of barrens by inclination classes shows that the destruction of forests on inclinations with inclination 25 %, followed by intensive pasturing, leads to the appearance of barrens. This hazard is much greater on inclinations of over 35 %, where over 90 % of the barrens are.

Altitude. A specific peculiarity of the impact of this feature of the relief in the studied watershed is that this impact coincides to a great extent with the impact of the human activity because the highest terrains are also the farthest from the village. For studying the impact of altitude, the watershed has been subdivided into four hypsometric belts:

H_I – (up to 900 m) – Low mountain – 199.4 ha (22.0 %);

H_{II} (900–1,000 m) – Low mountain – 268.6 ha (29.6 %);

H_{III} – (1,000–1,100 m) – High mountain – 251.4 ha (27.7 %);

H_{IV} – (over 1,100 m) – High mountain – 187.6 ha (20.7 %).

The results of this study are presented in Table 2.

Characteristics of the Hypsometric Belts

In H_I belt, the largest is the share of barrens (45.6 %), followed next by that of forests with severe erosion (21.1 %). The considerable percentage of forests protected against erosion (12.6 %) is due to

Table 2. The influence of altitude upon the distribution of areas.

Hypsometric belts	Total area of the terrain categories, ha/%						Index of erosion
	Ia	Ib	Ic	IIa	IIc	III	
H_I	12.6/8.5	8.4/10.4	21.1/43.5	9.5/16.7	2.8/9.6	45.6/45.3	0.70
H_{II}	36.3/33.3	27.4/45.6	15.6/43.4	2.2/5.2	0.5/6.5	18.0/24.1	0.34
H_{III}	32.4/27.8	20.7/32.2	5.0/13.1	9.7/21.4	7.7/55.1	24.5/30.6	0.37
H_{IV}	47.5/30.4	10.2/11.8	–	34.3/56.7	8.0/28.8	–	0.08

a great extent to the artificial forests there.

The better condition of the terrains in the next hypsometric belt is expressed mainly in the reduced proportions of the barrens (18.0 %) and the forests with severe erosion (15.6 %). Forests protected against erosion (36.3 %) and forests with moderate erosion (27.4 %) occupy most of the area.

In general, the situation in H_{III} type did not change substantially. Despite this, some differences can be noticed: the forest area decreases. Its reduction was the greatest for the class of forests with severe erosion – about 3 times. The clearing area increases to 17.4 %. The increased proportions of the clearing with severe erosion (7.7 %) and the barrens (24.5 %) are related to the influence of another source of anthropogenic impact. The higher parts of the watershed provide the natural linkage of pasture complexes in the higher portions of the mountain. Their more intensive utilization is due also to the circumstance that at these places, Zhelyavska River has permanent water flow and is used as a watering place for the local flocks and herds.

The state of the terrains in the uppermost belt is improving substantially. In this belt, there are neither barrens nor forests with severe erosion. Forests protected against erosion (47.5 %) and clearings (34.3 %) prevail.

The erosion index in the H_{II} and H_{III} belts decreased with certain fluctuations from 0.70, in H_I belt, down to 0.08, in H_{IV} one. Its values show that the state of the terrains is:

– H_I belt – very bad;
– H_{II} and H_{III} belts – bad;
– H_{IV} belt – very good.

Characteristics of the Categories

The forests protected against erosion are comparatively evenly distributed in the last three belts, where they occupy about 30 % of the total area. The forests with moderate erosion are best represented in H_{II} belt (45.6 %) and in H_{III} belt (32.2 %), which is indicative of their transitory location. As altitude decreases, the proportion of forests with severe erosion increases, as 86.9 % of their total area is in the first two belts.

The considerable proportion of the clearings protected against erosion in the lowest belt (16.7 %) is related mainly to the ownership of the lands there. In the other three belts, the proportion of IIa category increases from 5.2 %, in A_{II} belt, up to 21.4 %, in H_{III} belt, and up to 56.7 %, in H_{IV} belt. The distribution of the areas of clearings with severe erosion differs mainly in their largest proportion in H_{III} belt (55.1 %), as well as in their limited proportion in H_{IV} belt (28.8 %).

Table 3. The influence of exposure upon the distribution of the areas.

Exposure groups	Total area of the terrain categories, ha/%						Index of erosion
	Ia	Ib	Ic	IIa	IIc	III	
E_I	4.6/3.8	13.9/21.0	16.0/40.5	12.7/27.3	7.7/45.7	45.1/54.9	0.69
E_{II}	20.5/19.5	24.2/41.8	9.3/26.9	13.5/33.2	4.7/31.6	27.8/38.6	0.42
E_{III}	52.7/44.1	19.9/30.1	11.8/30.0	8.2/17.7	2.1/12.6	5.3/6.5	0.19
E_{IV}	69.1/32.6	8.3/7.1	1.8/2.6	17.8/21.8	3.0/10.1	–	0.05

The distribution of the areas with barrens shows their prevalence in H_I belt and their unavailability in H_{IV} belt. This is related to the influence of the anthropogenic activities there. It decreases with the increase of remoteness from the village.

Exposure. Expositions are united in four groups:

E_I – S и SW (of typically sunny exposure) – 244.6 ha (27.0 %);

E_{II} – W и SE (of the transitional sunny expositions) – 278.9 ha (30.7 %);

E_{III} – E и NW (of the transitional shady expositions) – 245.1 ha (27.0 %);

E_{IV} – N и NE (of typical shady expositions) – 138.4 ha (15.3 %).

The distribution of the area of each exposure group is presented in Table 3.

Characteristics of the Exposure Groups

On sites of typically sunny exposure, almost half of the total area (45.1 %) belongs to the coverage class of barrens. Next rank the forests with severe erosion (16.0 %). The share of forests protected against erosion is 10 times smaller than that of barrens. This distribution is due to not only the less favourable hydrothermal regime but also to the longer utilization, during the year, of these lands as pasture grounds.

The improvement of the situation on the transitional sunny expositions is expressed in the less striking difference between the percentage of barrens (27.8 %) and that of forests protected against erosion (20.5 %).

On the transitional shady expositions, over half of the area (52.7 %) is covered by forests protected against erosion. The percentage of forests diminishes, thus reaching its minimum value (11.8 %) with the forests with severe erosion. The barrens in this group occupy an area that is 10 times smaller than that of the forests protected against erosion.

The situation improves in the group with typical shady expositions. The clearly prevailing proportion in it is that of the forests protected against erosion (69.1 %), followed by that of the clearings protected against erosion (17.8 %). There are no barrens in this group.

The trend of a continuous improvement of the state of terrains, as expressed by means of the erosion index, shows the following arrangement:

E_I group – very bad;

E_{II} group – bad;

E_{III} group – good;

E_{IV} group – very good.

Characteristics of the terrain categories

Forests protected against erosion are uncommon on typical sunny expositions.

Their proportion increases up to 19.5 % on the transitional sunny expositions. This category is best represented on the transitional shady expositions (44.1 %) as well as on the typical shady ones (32.6 %). The forests with moderate erosion are the least numbered on the typical shady expositions (7.1 %). A considerable proportion of these forests (21.0 %) are on typical sunny expositions. Forests with severe erosion rarely occur on typical shady expositions. Their proportion in the groups with transitional expositions do not differ substantially. The largest part of the area belonging to this category (40.5 %) is on inclinations of typical sunny expositions.

The area of the clearings protected against erosion is comparatively evenly distributed in all exposure groups, ranging from 17.7 %, in E_{III} group, up to 33.2 %, in E_{II} group. The distribution of the area of the clearings with severe erosion shows a permanently diminishing percentage: from 45.7 %, on typical sunny expositions, down to 10.1 %, on typical shady ones. The differences between the two categories are due mainly to the steeper inclinations in IIc category.

The distribution of the area with barrens shows that over half of it (54.9 %) is on inclinations of typical sunny expositions.

The generalized data about the belonging of over 60 % of the total area of terrain categories to inclination classes, hypsometric belts and exposure groups, as well as their particular proportions within these, are presented in Table 4.

The information in Table 4 allows the following characterization of the terrain categories:

– Forests protected against erosion – very steep inclinations with shady expositions in the Middle and Low Mountain Belts;

– Forests with moderate erosion – very steep inclinations with transitional expositions in the Low and Middle Mountain Belts;

– Forests with severe erosion – very steep inclinations with sunny expositions in the Low Mountain Belt;

– Clearings protected against erosion – inclined inclinations with sunny expositions in the Middle Mountain Belt;

– Clearings of severe erosion – steep inclinations with sunny expositions in the Middle Mountain Belt;

Table 4. Distribution of the main part of the area by relief characteristics.

Category	Inclination		Altitude		Exposure	
	Class	Total area, %	Belt	Total area, %	Group	Total area, %
Ia	I_{IV} and I_V	87.6	H_{II} and H_{III}	61.1	E_{III} and E_{IV}	76.7
Ib	I_{IV} and I_V	80.1	H_{II} and H_{III}	77.8	E_{II} and E_{III}	71.9
Ic	I_{IV} and I_V	70.8	H_I and H_{II}	86.9	E_I and E_{II}	67.4
IIa	I_I	81.4	H_{IV} and H_{III}	78.1	E_{II} and E_I	60.5
IIc	I_{II}	71.5	H_{III} and H_{IV}	83.9	E_I and E_{II}	77.3
III	I_{III} and I_{IV}	65.7	H_I and H_{II}	69.4	E_I and E_{II}	93.5

– Barrens – steep and very steep inclinations with sunny expositions in the Low Mountain Belt.

Conclusion

The great diversity of the states and locations of the different categories of terrains is an expression of the complex combinations of the joint impact of the local relief characteristics and the anthropogenic activity.

The influence of inclination is most closely related to those of exposure and anthropogenic activity. The trend of intensification of erosion parallel with the increase of inclination is valid only for the sunny expositions. As inclination increases, on shady expositions a more favourable hydrothermal regime is established, and this facilitates the development of erosion-limiting vegetation.

Since the main source of impact is the village of Zhelyava, the influence of altitude coincides to a great extent with that of the remoteness from the village, i.e. the anthropogenic activity. With a few exceptions, erosion decreases with the increase in altitude.

Compared with the impact of the rest of the relief characteristics, the influence of exposure reveals the best-expressed trend for limitation of erosion with the transition from typical sunny expositions to typical shady ones. The hydrothermal regime improves in the same direction, and the anthropogenic impact is limited. This means that inclination exposure predetermines the effects of erosion to the greatest extent.

The distribution of the area of terrain categories into inclination classes, hypsometric belts and exposure groups confirms the decisive role of anthropogenic activity for the formation, development or control of erosion.

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COMPOSITIONAL ASPECTS OF THE TREES AND BUSH VEGETATION IN THE "ALBENA" RESORT

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Abstract

The trees&bush vegetation in the "Albena" resort can be viewed in two main groups, namely: I. Main plant capacities: local plant volumes; scaffolds-forming plant volumes; II. Secondary plant capacities: landscaping of the surrounding area of the buildings according to individual projects; plant collections and exhibitions. This analysis defines relationships and outlines guidance for the future development of the complex. The work is clarifying the structural connections between different types of plantation, the particular public parts of the complex and their functional capacity.

Key words: compositional aspects, plant capacities, vegetation, analysis, structural connections.

Introduction

The resort of Albena is situated 32 km north of Varna and just 12 km south-west of Balchik on a long sand stretch in the open northern part of Varna Bay. The resort's erection was started in 1968, which makes it one of the most modern holiday cities along the Bulgarian coast. The complex lies beneath a relatively high hill and is given particular charm by the near-by forest of Baltata, a part of which is declared a protected area. The latter is also called Batova Gora (Batova Forest) after the Batova river, in the valley of which it grows. The resort's architecture resembles one of Walter Gropius' urban models as most of the hotels have a terraced structure aimed at providing as much sun as possible in summer days. To the north the coast is steep, featuring yellow sandstone and limestone typical of the area. It is in fact this stone slope that was the main source of construction material for the resort.

Materials and Methods

Vegetation is a dynamic factor, which varies with mainstream of the time because of its biogenic nature and as a result of human activity. It is susceptible to sudden changes caused by natural or anthropogenic influences. The recreational activities can also lead to undesirable changes in trees&bush vegetation. This warrants a precise analysis of these characteristics that determine the recreational value of park areas and can be affected when these areas are used for recreational purposes.

Literature survey shows that the question of defining the indicators for recreational evaluation of parks is not fully resolved.

In most cases they are not related to their trees&bush vegetation. Therefore a lot of conclusions from most general matter were made. For example, Tandy (1979) recommended different aged and mixed plant volumes as more attractive for tourists. Preference to mixed plant volumes gives Brahe (1987) too, but he uses a quantitative measure for recreational assessment of the ornamental trees&bush vegetation - number of trees per unit area.

Deja (1981) does take into account the type and age of decorative plant volumes assessing the suitability of areas for recreation. The classification of different vegetation types is made according to species composition and soil moisture. Priority is given to the evaluation of mixed groups and massifs aged over 60 years and in certain habitats to the highest level of fitness have fallen ornamental trees&bush vegetation aged over 40 years.

Brush (1984) highlights the importance of high grasses and shrub plants as a horizontal limiting the visual intrusion in the areas, but it takes two criteria regarding age structure and species diversity of vegetation. Depending on the visual effects in some cases he recommended as more suitable different aged and mixed plant volumes, while in other cases – different aged and pure plant volumes.

According to Cooper and Murray (1992) a constructive method for visual evaluation of sites should include a description, analysis and classification of areas to create a structure within which to cover all landscape components. The biggest problem in the development of quantitative methods to evaluate the visual impact by Buhyoff and Riesenmann (1979) is to determine the coefficient of importance of individual landscape components in the overall evaluation. Unwin (1975) describes three stages in the evaluation of landscape: “measurement” of the landscape, formulation of landscape values through the survey of people’s preferences, and finally an evaluation of the visual qualities of the landscape. Most sophisticated models in this regard he says are psychophysical which use first psychological impact, and after that objective quantitative and qualitative parameters of the landscape. The creation of such a model requires three sets of data: photos, survey data on people’s preferences to landscape and landscape parameters.

Results and Discussion

This analysis is based on the vegetation monitoring in the period of 2007–2008 at the “Albena” resort with the aim of working up a plan for the future planning and development of the trees and bush arrays.

The trees and bush vegetation in the “Albena” resort can be viewed in two main groups, namely:

– Basic plant volumes:

Local plant volumes;

Scaffolds-forming plant volumes.

– Secondary plant volumes:

Landscaping of the surrounding area of the buildings under individual projects;

Plants for collections and exhibitions.

The natural vegetation in the complex forms the local plant volumes. First of all, this is the forest reserve “Baltata”, located near the village of Obrochishte and being the southern boundary of the resort. “Baltata” was nominated as a reserve on 20.04.1978 and later on 15.10.1999 it was redeterminated as a sustainable forest reserve. It is part of a dense forest in the north of Bulgaria, situated in the mouth of the Batova river. The arrays inside the complex, mostly on the slope of the complex, are also part of the local plant volumes. They are also of a natural origin and their structure is based mostly onto native species.

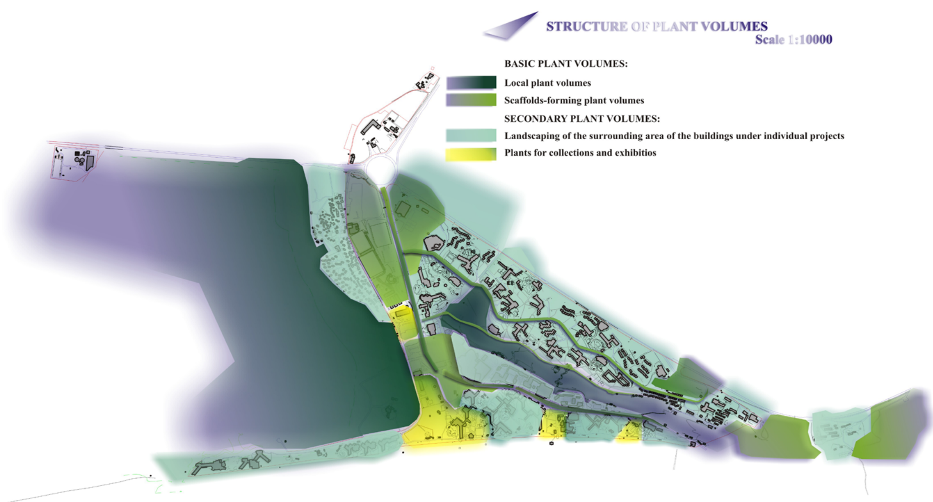
Scaffolds-forming plant volumes are arrays with an artificial origin of the tree species. They are constructed with typical area-resistant species. The street landscaping, which is a binding link between the different arrays in the complex, can also be attributed to the scaffolds-forming plant volumes.

Landscaping of the surrounding area of the buildings under individual projects holds a substantial part of the complex green areas. Together with the local plant species there are some ornamental plants as plant accents and compositional forms, which are not typical for the Black Sea region. The latter group – plants for collections and exhibitions – was presented only by the large rosarium, situated close to the promenade at the time of the study.

Conclusions

The general planning and the development concept of the complex provide the construction of many other special places with exotic plants in the future: playgrounds with collection of different harmless plant species, sitting areas with cactuses and other exotic tropical vegetation, palm trees in pots along the main pedestrian itineraries and major units of the local structural centers by means of the vegetation.

The conducted observations reveal clear and logical link between the func-



Structure of plant volumes

Certain basic and secondary plant volumes are defined. They form the spatial skeleton of the complex and contribute to its harmonious integration into the surrounding landscape. Parameters are referred to for further improvement of the green system of the territory. The maintenance and development of this trend will set “Albena” resort as an area with high ecological factor.

Fig. 1. Structure of plant volumes.

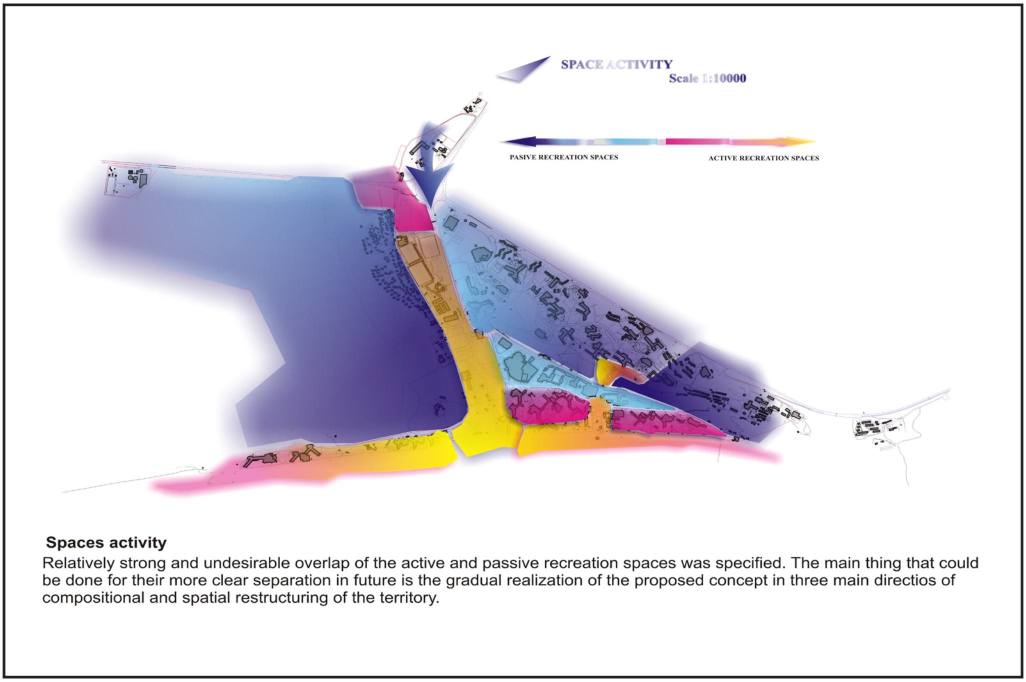


Fig. 2. Spaces activity.

tional activities of the areas and respectively the intensity and attractiveness of the plantations. That is illustrated by the two enclosed schemes (Figures 1 and 2).

This analysis defines relations and outlines guidance for the future development of the complex. The work clarifies the structural connections between the different types of plantation, the particular public parts of the complex and their functional capacity.

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CONCEPTION FOR COMPOSITIONAL AND SPATIAL RESTRUCTURING OF THE "ALBENA" RESORT

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Abstract

The proposed concept is a result of a two-year study of the components that have a direct impact on the optimal functioning of the resort. Object of the study were the following main components: spaces activity, isochron accessibility, functional zoning, scheme of mobile and pedestrian communications, structure of plant volumes. The aim of the study is to overcome some disparities connected with the existing commercial activities, administrative and municipal services, particularly as regards the methodology of selecting the site and offering of attractions. Certain basic and secondary plant volumes, which form the spatial skeleton of the complex and contribute to its harmonious integration into the surrounding landscape, are defined. Parameters are referred to for further improvement of the green system in the territory. The maintenance and development of this trend will set the resort of "Albena" as an area with high ecological factor. The concept includes ideas for reconstruction of: continuation of the axis from the main entrance of the complex as an organized attraction area; promenade with a proposal for a centrally situated park space in the middle of it; "Air lane" over the proposed park space for a link between the beach and the upper part of the complex; walking trails with viewing sites located on the same part. The established regularities and the proposed solutions contribute to the achievement of a modern and appropriate spatial structure of the complex with an improved combination of the social environmental factors with the existing natural landscape elements.

Key words: compositional restructuring, functional zoning, main components, spatial structure, walking trails.

Introduction

Tourism Resources structure is the basis for regional tourism development strategy and is the driving force behind the development of tourism according to Feng, Shaoqin and Tiefei (2005). The purpose of this study is to propose a better structure and better use of space in the resort in order to understand better the spatial behavior of tourists visiting spatially confined resort destinations which was developed by Debbage (1991). The evolutionary patterns in tourism well-founded by Papatheodorou (2004) demonstrate the need for such compositional and spatial restructuring of the „Albena“ resort.

Materials and Methods

The proposed concept is a result of a two-year study of the components that have a direct impact on the optimal functioning of the resort. The object of the study were the following components:

Isochron accessibility

The study points to a more definite separation of the residential areas and passive recreation from those spaces with greater potential for daily attendance. A more clear differentiation of these zones is outlined in connection with the distances from the central nucleus of the complex and the possibilities for direct access (Fig. 1).

Functional zoning

The aim of the developed functional zoning is to make the differentiation of the various areas and their rational consistency logical when situating them in the complex area. What is achieved is the overcoming some of the disparities associated with the existing commercial activities, administrative and municipal services, particularly as regards the methodology of offering of attractions.

Scheme of mobile and pedestrian communications

The schemes clarify the existing areas and communication lines in the complex. The new proposals clearly demarcate the pedestrian and the traffic flows and together with the outdoor and indoor parking facilities form an adequate communication network, which serves the entire complex.

Results and Discussion

The carried out studies and the reached conclusions led to the development of a wide range of ideas for reconstruction in all aspects of the landscape planning, the most important of which may be expressed in the following three main directions:

I. Extension of the main entry axis of the complex as an organized attractions area (Fig. 2).

The general compositional idea, though being in geometric shapes, has a dynamic character and it is associated with a rich presence of water as a symbol of activity and vitality. What is sought in the dynamic axial composition is the balance between water and green spaces and the merging side spaces, in which a number of various buildings and entertainment facilities can be located.

The significant presence of water that will be supplied in all its still or dynamic states (water mirrors, fountains, cascades, water mist) gives the area a waterpark (hydropark) character, hwhich, in combination with the other attractions, will undoubtedly become the main attractive place for the holidaymakers in the resort.

The composition is based on one main compositional axis and a secondary one. The first one gives room for more direct traffic. It is visually highlighted by a row of 5 fountains and comes to an end in a large glass dome. Atrium space with tropical and subtropical vegetation should be provided under the dome. The main gathering -distributional bodies are situated on this axis, as the entrances of the new spaces and the existing architectural spaces around are taken into account. The minor axis has a balancing character. It performs mostly a complementary function and at the same time accentuates the main compositional axis.

Overall, the space is planned as a broad attraction area which can be accessed gradually through the park area, where a new and modern multifunctional center is located at the place of the old cultural house. Arts and culture areas, information center, interactive rooms for children and adults, and entertainment places (restaurants, coffee bar, disco, etc.) will be located in this center.

A dolphin house, with a large outdoor swimming pool with an amphitheater stands nearby, is located near the promenade and in close proximity to the main compositional and pedestrian axis. Shell-shaped seats with closed canopy are provided for. This dolphin house will have an underwater link to the large glass dome (atrium) through which dolphins can be observed underwater through window displays.

So the atrium with its exotic vegetation will act as a huge aquarium with amusement places on its periphery.

The multifunctional nature of the environment and the even provision of activities at any time of the day were sought in the design of the composition.

In this way the „stillness" of certain areas at certain times of the day will be avoided.

II. Sea promenade with a park area and an "air promenade" as a link between the beach and the upper part of the complex.

The developed idea of an "air lane" in the central part of the complex is not traditional for our country, especially in terms of the landscape architecture. The so-called "hanging promenades" – coastal, riverside and lakeside leisure lanes, built on a relatively high level above the water surface – have already analogues in the world. However, the building of such promenades has always been a great challenge both for the authors of such projects and also for the institutions that would approve and fund such an endeavour.

Based on an extensive preliminary research and analysis within the Albena resort, we found the presence of adequate natural (climate, water, vegetation, topography) and socio-economic potential of the complex, which presumes the possibility of creating such a recreational and attractive oasis.

The design concept is based on an innovative approach: generation of the original idea, binding it with the aesthetic and functional requirements for the creation of both the specific area and its harmonious integration as an autonomous unit park into the general compositional plan (Fig. 3).

Broadly speaking, the concept is built on the idea of creating a modern aesthetic pedestrian link from the top level (panoramic promenade) to the lowest level (sea promenade).

During the development of these two structure formation paths for the whole complex an issue arose regarding the expedience of their connections in an original, but rational and natural way in subjection to the existing urban and landscape structures.

The idea is to make this connection in 3 or 4 levels, so that one of the levels, the one having the smallest area, to go over the new transport artery.

The lowest level of the structure, which is planned to be above the sea level has a height of about 6–7 m and it is the so-called "air alley", or rather, "air terrace". This level has the largest area and it has the largest recreational capacity and high degree of popularity. The concept of the park decision, which is developed at the level of the sea promenade below, should be achieved like a "bird's eye" view.

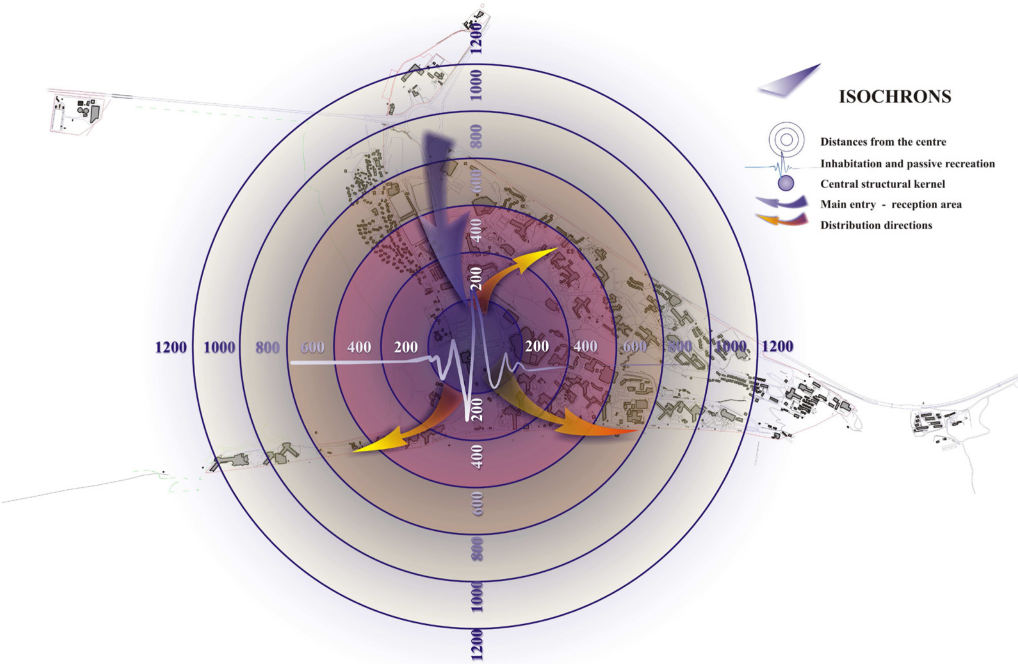

Fig. 1. Isochrons.

Therefore, the shape of this “air alley” is like a promenade ring which surrounds the park area below and reveals beautiful views both to it and to the sea skyline.

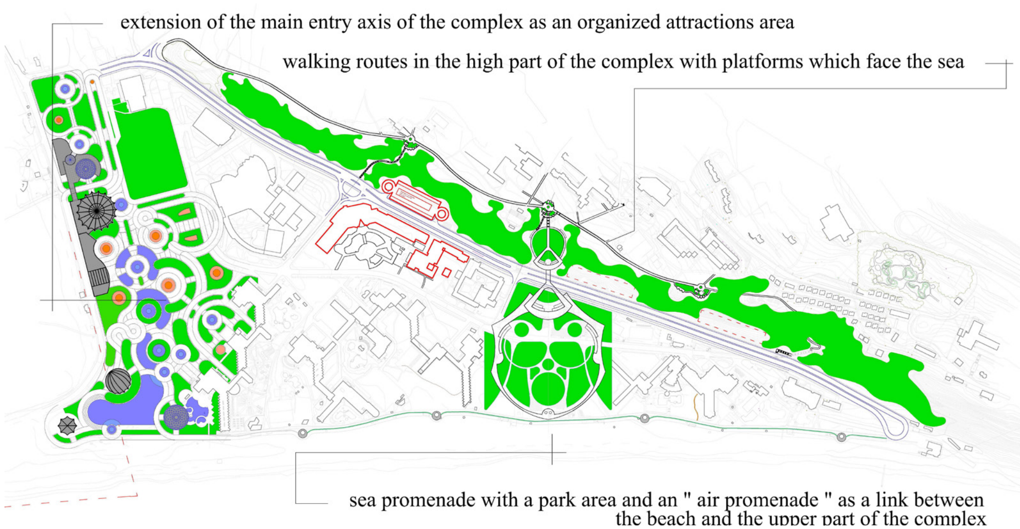

Fig. 2. Scheme of the resort.

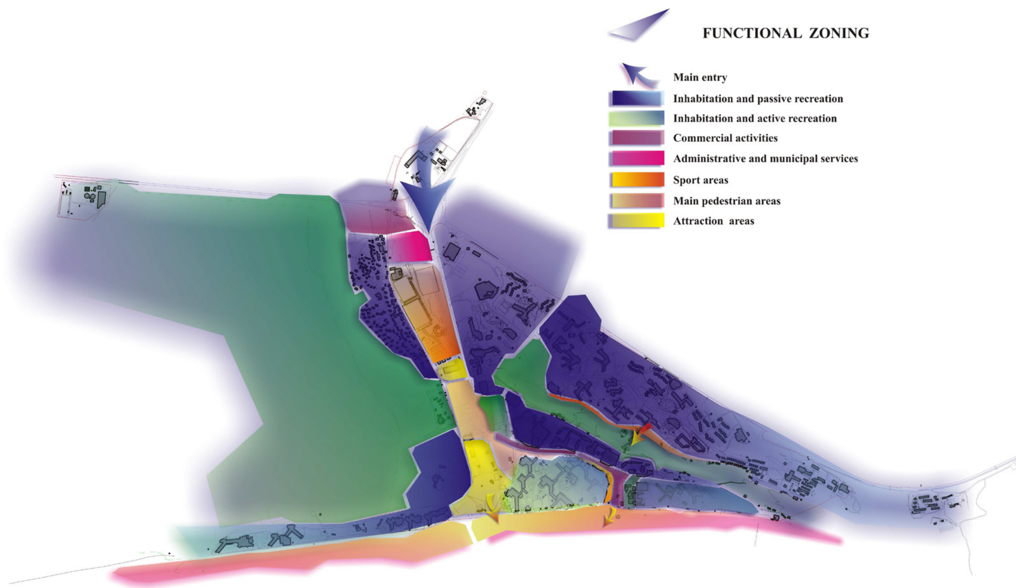

Fig. 3. Functional zoning.

The site is planned to be provided with various and vanguard architectural and sculptural elements, water mirrors, small trade outlets around the bearing columns of the structure etc.

The main effect of this idea plan relies on the harmonious merging of the sea promenade with its deviations below with the ramps, stairs and elevators of the “air alley”.

Fig. 4. Scheme of communications.

The lateral situation of the "air alley" towards the tree and bush vegetation below will give the strolling people the allusion that they walk among the tree branches and over the tree crowns.

III. Walking routes in the high part of the complex with platforms which face the sea (Fig. 4).

The relief features of the terrain of the complex have predetermined its natural division into two parts, which until now have not always been linked in a satisfactory way both in terms of communication and functionality. The steep slope, which is the dividing boundary of these two parts, is planted with bush-tree massives. This vegetation is not healthy and its aesthetic impact is quite low.

The proposal of the present frame of reference is to make these massives and all the north-eastern part of the complex part of the total volume-spatial plant composition of the complex with carrying out the following specific activities of forestry intervention:

- sanitary felling, applied to the whole area of the plantation, in order to remove the dead, diseased and heavily damaged specimen;
- cleaning felling in the major part of the plantation area to create a growth space for the trees;
- partial reforestation of the plantation in order to restore the environment where an excessive thinning out of the forest stand has occurred;
- moulding of the retaining walls and earth slopes after the construction of the new transport thoroughfare at the foot of the slope;
- shaping the periphery of the plantation on the upper edge of the slope.

Architectural and artistic intervention:

- creation of one major and three minor new pedestrian links between the lower and upper part of the complex, which should overcome the displacement of the steep slope through a series of stairs and ramps in a serpentine line;
- creation of a principal panoramic promenade;
- shaping three large and several smaller spots along the alley at the top of the slope to ensure better walking conditions and revealing beautiful landscape views to the sea;
- shaping the panoramic promenade itself with appropriate paving, benches pockets and others park elements.

Conclusions

The established regularities and the proposed solutions will contribute to the achievement of a modern and appropriate spatial structure of the complex with an improved combination of the social environment factors with the existing natural landscape structure.

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CLASSIFICATION OF FOREST VEGETATION ON THE SOUTH SLOPE OF VITOSHA MOUNTAIN, WESTERN BULGARIA

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Abstract

In the last decades numerous studies have presented vegetation classifications. Some of them highly subjective, relying entirely on qualitative data, others more objective, based on quantitative information, susceptible to statistical tests. On that ground, vegetation organization was viewed either as composed of recognizable community units or as a continuum with gradually changing composition, provoking continuous debate. This study represents numerical classification of forest vegetation on the south slope of Vitosha Mountain, Western Bulgaria. We hypothesized that described community types will not hold the statistical test for their consistence. Stratified sampling procedure and nested 0.1 ha sampling plots were used. Obtained field samples were classified with TWINSPAN clustering method. Resulting groups were tested for statistical difference for the most important environmental gradients and vegetation variables. 114 field samples were collected and grouped in nine forest community types. Six of them are dominated by *Fagus sylvatica* L. Two are coniferous forests (plantations), where *Pinus nigra* Arn. and *Pinus sylvestris* L. are most abundant. The last one is mixed oak forest. Beech forests predominate at higher elevation, in more mesic habitats and on steeper slopes. Most of the beech communities have significantly higher canopy closure and lower shrub and herb strata cover. Mixed oak forest and coniferous communities are richest in almost all life and growth forms. They are more susceptible to invasion, because of their proximity to populated areas and severe disturbance regime, therefore richer on alien species. Mixed oak forest and coniferous communities also have significantly higher species richness per 0.1 ha and 1 m^2, as well as higher alpha diversity and evenness. All forest communities in the studied region are poor in rare, protected and endemic species. Despite the significant differences between some of the *Fagus sylvatica* communities and the mixed forests, they are generally unrecognizable statistically from each other. Therefore, the vegetation of the studied area is considered as having continuum organization. Numerical classification, relying on quantitative and statistically testable data, will objectify and simplify vegetation understanding and improve future management activities.

Key words: numerical classification, TWINSPAN, forest vegetation, community types.

Introduction

The question about vegetation organization, whether it is composed of recognizable community units or as a continuum with gradually changing composition, has a long history of debate between the different ecology schools (Austin 2005).

Communities are assumed to have consistent floristic composition, uniform physiognomy, occupy unique environment, and occurring in several locations. On the other hand, continuum concept states that each species has individualistic response to biotic and abiotic conditions and when vegetation is viewed in the context of environmental gradients, its composition and structure changes continuously (Austin 2005).

Cluster analyses in vegetation ecology are used for classification of samples, species or environmental variables. Despite the continuous nature of the data, classification is a method for identification of cluster among the raw data and helps to reveal the hidden data structure, i.e. continuum division on system of provisional types or classes. The basic objectives in classification studies are: 1) gathering information on species coexistence (hidden data structure); 2) establishing of community types in descriptive investigation (vegetation mapping); and 3) revealing the relationship between vegetation and environmental gradients through analysis of delineated groups in the context of environmental variables (van Tongeren 2004).

In the last 20 years several classifications of beech forests on the Balkans have been presented, basically from neighboring Serbia. These are concerned mainly with syntaxa naming, and their rearrangement in hierarchical syntaxonomical scheme, as well as revision of already proposed names (Tzonev et al. 2006). Several floristic beech forest analyses have been carried out on the Balkan Peninsula nowadays. They cover the territories of Macedonia (Dzwonko et al. 1999, Dzwonko and Loster 2000), Greece (Dzwonko and Loster 2000, Bergmeier and Dimopoulos 2001, Tsiripidis et. al. 2007b) and Bulgaria (Tzonev et al. 2006).

Beech forests in Bulgaria are broadly distributed and cover approximately 17 % (together with *Fagus orientalis* Lipsky forests) of the forested territory (Garelkov and Stiptsov 1995). Existing studies have mainly local scale and most of them follow Russian school methodology (Tzonev et al. 2006). Recently, attempts for phytosociological classification of beech communities have been made (Pavlov 1998), as well as forest typological ones (Garelkov and Stiptsov 1995). In the last years, local studies using Braun-Blanquet approach, have been realized too (Pavlov and Dimitrov 2003, Dimitrov and Glogov 2003).

Previous classification studies were burdened with high extent of subjectivity. First, subjectivity comes from the employed field method and sampling procedures. Second, the type of gathered information (mainly qualitative) and its further processing results in unsuitable for statistical tests community types. Development of numerical classification methods though is solving this issue. Unfortunately, these methods are weakly known or reluctantly used by great number of ecologists.

Despite the numerous botanical and ecological studies so far they have not brought an integrated picture about the pattern (composition and structure) of the studied vegetation. This particular territory has been chosen because it is weakly known and relatively spared from human disturbances nowadays.

In contrast to the previous studies, setting of sample plots in the current investigation is based not on intuitively identification of plant associations, but rather on the relationship of the samples with environmental gradients. Following this way, the current study aims to reveal the relationship between vegetation and environment on the basis of species population response to environmental gradients (Whittaker 1956), considering it more objective and adequate.

The current study is an attempt to expand and clarify the accumulated knowledge on the basis of more objectively gathered samples, quantitative data and statistical test of the described community types. Quantifying and objectifying of classification process will facilitate vegetation understanding in terms of its composition and structure and will improve the future management of the area. This paper also tries to answer the question whether plant communities are clearly recognizable units in the environmental space or part of the vegetation continuum, indistinguishable from each other? Answering this question will bring support to one of the competing paradigms and help clarifying vegetation ecology theory.

Study area

Vitosha Mountain is located in Western Bulgaria. Since it is a relatively young mountain (Shipkova 2005), it is characterized with compactness and well expressed elevation gradient. The mountain has steep slopes and variable expositions. Its vegetation has varied and rich species composition. Most of the mountain's territory is declared Nature Park by the Bulgarian legislation. The current study embraces the south slope of the mountain, covering all forested habitats. GPS coordinates of that territory are between N42°32' E23°09' and N42°26' E23°21'. This area covers 118 km^2.

Vitosha Mountain is formed during the late Cretaceous and early Tertiary period. The most widely distributed bedrocks are Paleozoic sediments and early Mesozoic sediments. The highest peak is Cherni peak reaching 2290 m (Shipkova 2005).

Mean annual rainfall is between 650–700 mm in the mountain's base and around 1000 mm in the highest parts. Annual rainfall distribution has one peak and most of the precipitation falls in April-July period. The most arid period is late summer and early autumn. The highest parts of the mountain (above 1800 m) almost all year round are exposed to strong southwest and west winds, reaching up to 8 $m \cdot s^{-1}$ (Koleva 2005).

Vitosha Mountain has a great variety of soils. The lowest mountainous parts are dominated by *Chromic Cambisols*. In the elevation belt 1400–1750 m the most widely distributed are *Cambisols*. In the highest parts of the mountain (1750–1900 m) *Mollic Cambisols* prevail. In the subalpine and alpine zones *Umbrosols* are formed. *Fluvisols* are present along the lower river beds (Malinov 2005).

Vitosha's natural vegetation was developed during the last ice age. According to palaeobotanical studies the floristic composition of the territory has not changed essentially. Substantial vegetation alteration took place later, mainly due to human activity. During the 15–19 centuries, mining, primitive metallurgy and nomadic cattle-breeding were developed in the region. The need of wood materials led to forest clearing over most of the mountain. Finding of pasture for the numerous herds necessitated setting of periodical fires in the high mountainous parts. This resulted in almost complete destruction of the natural vegetation. These factors, together with the steep relief and the exposed to heavy rain soils, led to developing of erosion processes and subsequent degradation of the natural habitats (Meshinev 2005).

Material and Methods

Sampling

In the summers of 2008 and 2009, systematically, along a preliminary drawn vertical transects on the south slope of Vitosha Mountain, 114 0.1 ha (20x50 m) vegetation plots were laid (Figure 1). Totally nine transects, following the main and intermediate Earth directions (E, EES, ES, SSE, S, SSW, SW, SWW, and W) were set. Transects start at around 900 m and reach the tree line. The plots were set at uniform distance of 50 m altitude along the vertical transect. Starting position of transects is randomly chosen after numbering of five possible starting points and pulling one of them. Sampling places are located in such a way so they can cover the maximum variety of expositions, slope inclinations, slope topography and elevations. There is no need for sampling sites representing some obvious or assumed species association, neither transition between them. The exact sampling sites are chosen visually keeping the requirement for vegetation homogeneity, i.e. they should not be located in the forest periphery or in large open forest patches. Forest communities under intensive human influence (intensive livestock grazing or logging) were avoided. In order to avoid spatial autocorrelation the distance between neighboring sampling plots was at least 200 m.

On the place chosen, 50 m plastic tape was laid on the ground, perpendicular to the topographic horizontals. From the two ends of the tape toward its two sides, perpendicular to it, 10 m distance was meas-

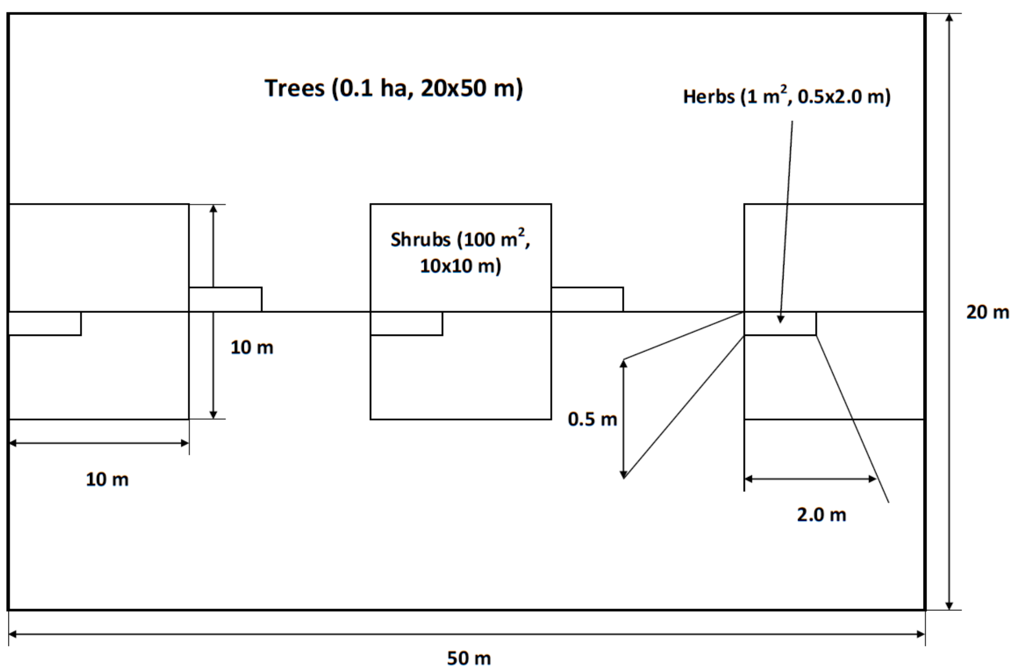

Fig. 1. Nested sampling plot, modified from Whittaker (1956, 1960).

ured and metal stakes were fixed into the ground. Obtained in this way rectangular plot has 20x50 m sides (Figure 1). First, total tree stratum cover was measured visually in percents. Then diameter of all tree and shrub stems >1 cm at breast height (≈1.30 cm) was measured by species and grouped by diameter classes.

In the 0.1 ha plot, along the tape, at interval of 10 m (as it shown on Figure 1), three quadrate 10x10 m subplots were set. In these subplots, total cover of shrubs <1 cm at breast height or less than 2 m high, was measured visually and then by species. Along the tape again, at intervals of 8 m, five sub subplots 0.5x2 m (with the long side parallel to the tape) were set. Whether to be on the left or right side of the tape was determined by throwing a coin. In these sub subplots, total cover of herb stratum was measured visually and then by species also. Depending on the spatial heterogeneity of the herb stratum, in some of the plots between 2 and 10 sub subplots with an area of 1 m^2 were laid, but generally five, as shown on Figure 1. Finally, the whole 0.1 ha sampling plot was searched again and on the species not recorded already was given minimal score for the Importance Value (IV).

IV is a generalized expression of the quantitative share of different species in the plant communities. It combines measured on the field particular values like cover, density, frequency, biomass etc. of the plant species. IV calculation for the different species in all vegetation strata was done in the following way:

Tree and shrub stems >1 cm at breast height (canopy stratum):

IV=relative density (number of individuals) per 0.1 ha.

Tree and shrub stems <1 cm at breast height (or less than 2 m height) (shrub stratum):

IV=mean cover per 100 m^2 +frequency$\cdot 2^{-1}$.

Trees, shrubs and herbs (herb stratum):

IV=mean cover per 1 m^2+frequency$\cdot 2^{-1}$.

IVs for a given species from different strata were summed. Cover was estimated visually in percents (0–100 %) and frequency was calculated by the following formula:

$$C_f = \frac{a}{b}.100(\%), \quad (1)$$

where:

a=number of subplots (for shrub stratum) or sub subplot (for herb stratum), where the species was present;

b=total number of sampling subplots or sub subplots.

In each 0.1 ha plot elevation was measured with barometric altimeter. At the beginning of the tape, the exact coordinates were measured with GPS (General Pointing System) device. Slope inclination in each 0.1 ha plot was measured in degrees with clinometer. Exposition was determined with GPS compass. Gathered in this way data were used directly in the analyses or were categorized.

Expositions were categorized in the following way (Whittaker 1960): 1=N, NE, NNE, deep moist ravines near temporary or permanent streams; 2=EEN, NNW; 3=E, NW; 4=EES, WWN; 5=SE, W; 6=SSE, WWS; 7=S, SW, SSW, ridges and hills. Categorized in this way the expositions are arranged from the moistest to the most xeric. Slope topography was categorized in similar manner: 1=concave slope; 2=flat slope; 3=convex slope. Measured slope inclination and elevation were directly used in the analyses without further change.

Unidentified on the field individuals were taken as herbarium specimens and transported to the University of Forestry's laboratory for species identification. Nomenclature and systematic follow Jordanov (1989) and Kojuharov (1995), as well as Delipavlov (1992) and Javorka (1975).

Classification

In the current study TWINSPAN classification (Two Way INdicator SPecies Analysis) (Hill 1979) was used. The basic idea in TWINSPAN is that each group of samples can be identified on the basis of indicator species, i.e. such species that prevail at the one side of the dichotomy. TWINSPAN gives the opportunity of processing qualitative and quantitative data. The software TWINSPAN not only classifies the samples but produces two-way ordered data table (samples x species). In the construction of the TWINSPAN table, two-way weighted average algorithm of Correspondence Analysis (CA) (Hill 1973) was used. Combination of the two has made the method one of the most popular among the vegetation ecologists nowadays (van Tongeren 2004).

As a measure of relative homogeneity of the community types, index of homotoneity was used (Curtis 1959). Curtis (1959) defined it as the sum of frequency of the dominant species divided by the sum of frequency of all species and multiplied by 100, i.e. it is the average frequency of dominant species. Dominant species (sensu Curtis 1959, Peet 1981) were specified by calculation of frequency of all species in given community type. Then, the mean species number in that community type was calculated [this is the species density, *d*, of Curtis (1959)]. Dominant species are these *d* species with greater frequency. Homotoneity index has the advantage of relatively independency of the sample number in the community type, because species density reaches constant after the first few samples (Peet 1974, Peet 1981).

Species Diversity

We estimated species diversity using the heterogeneity index of Hill (1973) N_2. It is less dependent on species number and sample size (Baev and Penev 1995). Moreover, it is simple and easy for interpretation (Peet 1974). The index was calculated as follows:

$$N_2 = (\sum_i p_i^2)^{-1}, \left(i = 1,2,3\ldots,S\right), 0 \le N_2 \le S, \quad (2)$$

where, p_i is the sample proportion, belonging to i-th species.

The second diversity aspect, used in this study, is evenness, which Pielou (1975) defines as the relationship of diversity index and the maximum diversity value, which the sample can have, given the same species number. Hill's (1973) index of evenness E' was used. According to Peet (1974) it depends only on the diversity indexes and does not depend on the sample size. It is a "new and useful way for species diversity investigation" (Peet 1974). It was calculated as follows:

$$E' = \frac{N_2}{N_1} = \frac{\left(\sum_i p_i^2\right)^{-1}}{exp\left[-\sum_i p_i ln(p_i)\right]}, \quad (3)$$

where, p_i is the sample proportion, belonging to i-th species.

Community types were compared and tested for statistically significant difference with nonparametric (when the distribution was not normal) Kruskal-Wallis ANOVA on Ranks, Dunn's test. When the distribution was normal we used One-Way ANOVA, Holm-Sidak method. In all analyses the significance level was $P \leq 0.05$. The following software products were used: STATISTICA, version 8.0 (StatSoft 2007), TWINSPAN for Windows (Hill and Šmilauer 2005), version 2.3, CANOCO for Windows, version 4.51 (ter Braak and Šmilauer 2003), CanoDraw for Windows, version 4.1 (Šmilauer 2003), SigmaPlot for Windows, version 11.0 (Systat Software Inc. 2008).

Results

In the summers of 2008 and 2009, 114 0.1 ha sampling plots were set. 353 vascular plant species were found. Nine of these were not determined to species level, because of unsuitable phenological phase or missing parts and have been excluded from the following analyses.

DCA (Detrended Correspondence Analysis) (Hill and Gauch 1980) gradient length of forest vegetation data was 4.574 SD units, thus justifying employment of TWINSPAN method with its CA division algorithm. Analysis was carried out with the default options checked. Three levels of division were used because they gave us the desired combination between detail and interpretation capability (Table 1). TWINSPAN classification resulted in eight community types. One of the TWINSPAN groups (containing samples from pine plantations) was divided additionally into two community types (*Pinus sylvestris-Fragaria vesca* and *Pinus nigra-Crataegus monogyna*) because they had different dominant tree species and were significantly different in some environmental and vegetation variables. Mean species number per 0.1 ha was 34.4 species, and 4.4 m^{-2}. In six of all forest communities, *Fagus sylvatica* was the dominant tree species. In the other three community types *Pinus sylvestris, Pinus nigra, Quercus cerris* L.*, Quercus petraea* (Matt.) Liebl., *Carpinus betulus* L.*, Crataegus monogyna* Jacq. and *Cornus mas* L. dominated.

Studying the Wisconsin vegetation, Curtis (1959) found that homotoneity varied between 34.5 and 70.3. Peet (1981) studied geographically restricted and less diversified forest communities and found that their homotoniety varies between 54.5 and 78.5. We obtained values from 52.3 to 70.5 (Table 2). Most homogenous are coniferous forests and *Fagus sylvatica-Hepatica nobilis* community type.

TWINSPAN analysis of the studied vegetation showed compositional gradient beginning from mesic beech forest (from left to right in Table 1), through submesic and subxeric beech communities, to subxeric and xeric coniferous forest, and xeric oak community. Mesic beech forest was represented by *Fagus sylvatica-Hepatica nobilis* and *Fagus sylvatica-Physospermum cornubiense*. Submesic beech forest included *Fagus sylvatica-Gallium odoratum, Fagus sylvatica-Luzula luzuloides* and *Fagus sylvatica-Festuca drymeja*. The last beech community, *Fagus sylvatica-Corylus avellana-Brachypodium pinnatum*, had more xeric nature. *Pinus sylvestris-Fragaria vesca, Pinus nigra-Crataegus monogyna* and *Quercus cerris-Cornus mas* forest communities were also located in the xeric part of moisture gradient.

Forest Community Type Description

Community names are combination of two or three species names with greatest Importance Value (Table 1). Most often, these were the dominant species in the different vegetation strata. In this section detailed description of community types is presented.

Fagus sylvatica-Hepatica nobilis (*n*=8). Communities of this type are distributed at mean elevation of 1214±30.7 m on steepest slopes with north, northeast and northwest exposition. Slope topography is variable, but mainly with flat and convex form. These forests prefer mesic habitats. Most important species are *Acer campestre* L., *Carpinus betulus, Acer pseudoplatanus* L., *Acer platanoides* L. and *Fraxinus ornus* L. Dominant shrubs are *Cornus mas*, *Crataegus monogyna, Lonicera xylosteum* L., *Corylus avellana* L. and *Rosa canina* L. Herb species with highest IV are *Physospermum cornubiense* (L.) DC., *Lamiastrum galeobdolon* L., *Campanula rapunculoides* L., *Viola riviniana* Rchb., *Galium odoratum* (L.) Scop., *Lathyrus vernus* Bernh. and *Cruciata glabra* (L.) Ehrend. Mean species richness per 0.1 ha is higher compared to the other beech communities. That applies to the mean species richness per 1 m^2 also. This community type has relatively high species diversity and evenness.

Fagus sylvatica-Physospermum cornubiense (*n*=12). These communities are distributed at mean elevation of 1268±19.6 m, mainly on steeper north and northwest facing slopes, in mesic and submesic habitats. Slopes have variable topography, but basically with flat and concave surface. Tree species with highest importance are *Carpinus betulus, Populus tremula* L., *Prunus avium* L., *Acer campestre, Crataegus monogyna* and *Prunus cerasifera* Ehrh. The shrubs and herbs are poorly represented. Most important are shrubs like *Rosa canina* and *Corylus avellana,* and herbs like *Helleborus odorus* Waldst. & Kit., *Viola riviniana, Luzula luzuloides* (Lam.) Dandy, *Lamiastrum galeobdolon, Melica uniflora* Retz., *Galium odoratum, Mycelis muralis* (L.) Dumort. and *Hepatica nobilis* Mill. These forests are poorer on species at the two scales. Diversity and evenness indexes are lesser too.

Fagus sylvatica-Galium odoratum (*n*=13). These forests are distributed at mean elevation of 1433±39.1 m, mainly on flat and concave steep slopes with northern and eastern exposition and mesic habitat conditions. Dominant trees, together with the *Fagus sylvatica*, are *Picea abies* (L.) Karst., *Pinus sylvestris, Tilia platyphyllos* Scop. and *Sorbus aucuparia* L. The herbs are well represented. The most important species are *Oxalis acetosella* L., *Lamiastrum galeobdolon, Aremonia agrimonoides* (L.) DC., *Mycelis muralis, Luzula luzuloides* and *Dryopteris filix-mas* (L.) Schott. With the greatest importance values among the shrubs are *Rubus idaeus* L., *Corylus avellana* and *Lonicera xylosteum*. Mean species richness per 0.1 ha is high for beech forest as well as that at 1 m^2. Diversity and evenness are also higher.

Fagus sylvatica-Luzula luzuloides (*n*=23). This community type is found at mean elevation of 1415±26.0 m, mostly on convex or rarely on flat steep slopes, on variable expositions, but mainly on east, northwest and southeast ones. The mean tree stratum cover is rather high. Together with *Fagus sylvatica*, here dominate species like *Picea abies, Prunus cerasifera, Crataegus monogyna* and *Sorbus aucu-*

Table 1. TWINSPAN classification of forest vegetation. For all environmental gradients and vegetation variables, means ±SE are shown.

TWINSPAN level 1	**Forest communities dominated by (*Fagus sylvatica*)**						**Mixed forest communities dominated by *Pinus* and *Quercus* genera**		
TWINSPAN level 2	**Mesic beech forests**			**Submesic beech forests**		**Subxeric and xeric beech forests**	**Subxeric and xeric coniferous forests (plantations)**		**Mixed xeric oak forests**
Community types	*Fagus sylvatica-Hepatica nobilis* (*n*=8)	*Fagus sylvatica-Physospermum cornubiense* (*n*=12)	*Fagus sylvatica-Galium odoratum* (*n*=13)	*Fagus sylvatica-Luzula luzuloides* (*n*=23)	*Fagus sylvatica-Festuca drymeja* (*n*=17)	*Fagus sylvatica-Corylus avellana-Brachypodium pinnatum* (*n*=15)	*Pinus sylvestris-Fragaria vesca* (*n*=15)	*Pinus nigra-Crataegus monogyna* (*n*=5)	*Quercus cerris-Cornus mas* (*n*=6)
Community type abbreviation	A	B	C	D	E	F	G	H	I
Environmental gradients									
Mean elevation, m	1214±30.7	1268±19.6	1433±39.1	1415±26.0	1332±20.7	1310±40.6	1304±29.0	989±24.3	1024±18.3
Mean moisture index (xerophytism)*	1.50±0.27	2.75±0.45	2.38±0.46	3.04±0.32	3.00±0.54	5.13±0.43	4.27±0.56	3.20±0.97	3.83±0.70
Mean slope inclination, °	28.25±1.78	20.83±1.97	21.77±1.64	23.39±1.20	20.53±1.40	19.27±1.50	13.00±1.80	13.80±2.48	19.00±2.52
Mean topography index (slope convexity)**	2.00±0.27	1.92±0.19	1.92±0.21	2.48±0.14	2.29±0.11	2.07±0.15	1.93±0.12	2.20±0.20	2.50±0.22
Mean cover, %									
Tree stratum, 0.1 ha	86.25±1.83	87.50±0.97	84.23±2.76	86.87±1.98	88.06±1.64	72.33±4.97	74.00±2.85	67.00±2.55	69.17±7.00
Shrub stratum, 100 m^2	0.89±0.41	0.93±0.36	1.61±0.53	1.29±0.41	1.89±0.79	13.99±5.99	6.70±2.31	4.39±1.87	4.64±3.16
Herb stratum, 1 m^2	7.61±2.73	3.73±1.04	17.36±4.71	3.56±0.61	6.72±2.33	12.61±2.85	25.66±3.94	8.54±1.97	15.54±3.65
Life form (Raunkiaer 1934) (mean species number per 0.1 ha)									
Phanerophytes	9.38±0.92	4.75±0.46	5.31±1.02	2.87±0.37	2.00±0.31	9.73±0.78	12.47±0.98	19.60±1.29	12.83±2.33
Chamaephytes	-	-	0.15±0.10	0.35±0.12	0.29±0.14	-	0.53±0.19	0.60±0.24	0.67±0.33
Hemicryptophytes	21.88±1.19	18.00±1.96	26.15±3.26	16.26±1.28	7.53±0.88	25.40±2.07	28.93±2.17	35.40±5.77	29.83±3.95
Cryptophytes	4.50±0.33	1.33±0.33	1.85±0.32	0.35±0.10	0.06±0.06	0.40±0.13	0.20±0.11	-	1.17±0.17
Therophytes	0.25±0.16	0.67±0.33	0.85±0.37	1.00±0.24	0.47±0.19	0.80±0.34	2.27±0.38	1.60±0.51	1.00±0.37
Growth form (mean species number per 0.1 ha)									
Trees	3.75±0.56	3.00±0.33	3.00±0.48	1.43±0.14	1.65±0.24	4.00±0.57	5.13±0.53	9.40±1.08	4.83±0.87
Shrubs	5.63±0.75	1.75±0.37	2.46±0.58	1.78±0.38	0.65±0.19	5.73±0.42	7.87±0.72	10.80±0.97	8.67±1.45
Semishrubs	-	-	-	-	-	-	0.07±0.07	-	-
Perennials	26.00±1.32	19.17±2.10	27.31±3.14	16.26±1.28	7.59±0.90	25.20±1.89	28.20±2.11	34.20±5.46	30.67±4.22
Biennials	0.25±0.16	-	0.38±0.18	-	-	0.33±0.16	0.47±0.19	1.00±0.55	0.67±0.49
Annuals	0.38±0.26	0.83±0.41	1.15±0.39	1.35±0.27	0.47±0.19	1.07±0.36	2.67±0.44	1.80±0.58	0.67±033

* – For more details see exposure categorization; most xeric sites are with highest values; ** – for more details see slope topography categorization.

Table 2. TWINSPAN indicator species, diversity and homotoniety of forest community types (for the diversity indexes, means ±SE are shown).

Indicator species	A	B	C	D	E	F	G	H	I
Athyrium filix-femina (L.) Roth.	0[a]/0[b]	0.4/8.3	**3/62**	0/0	0/0	0/0	1/20	0/0	0/0
Clematis vitalba L.	0/0	0/0	0.4/8	0/0	0/0	0/0	0.4/6.6	**8.8/80**	**2.5/50**
Cornus mas**	9/38	0.4/8.3	0/0	0/0	0/0	3.7/7	0.7/13	**6/80**	**41/67**
Crataegus monogyna	6/38	2/42	0.4/8	1.2/13	0/0	**8/87**	**9/67**	**41/100**	**27/83**
Dactylis glomerata L.	0/0	0.4/8	2.4/23	0.9/13	0.3/6	**10/100**	**7/60**	**24/100**	**23/83**
Epilobium montanum L.	0/0	0.8/16.7	2.3/31	2.4/48	0.3/5.9	1/20	**6/86.7**	5/60	0/0
Euphorbia cyparissias L.	0/0	0/0	0.4/8	0/0	0/0	**2/33**	**5/87**	**10/80**	**8/50**
Fragaria vesca L.	0.6/13	0.4/8	7/39	0.4/9	0/0	**11/87**	**24/100**	**17/80**	**0.8/17**
Galium odoratum	12.5/50	7.6/58	**22/92**	4.3/35	0/0	0.7/13	2.4/33	0/0	0/0
Helleborus odorus	**7/100***	**11/100**	6/54	4.5/52	0.3/6	11/7	2/40	4/60	19/83
Hepatica nobilis	**22/100**	6.4/41.7	3/23	0.9/17.4	1.2/5.9	0.5/6.7	0.4/6.7	0/0	5.2/33
Juniperus communis	0.6/12.5	0.4/8.3	0/0	1.5/4.3	0.6/12	**9/40**	**19/80**	0/0	0/0
Lamiastrum galeobdolon	**16/75**	**8/83**	**17/77**	**7/57**	**3/53**	0/0	1.4/13	0/0	3/17
Lonicera xylosteum	**4.4/88**	0/0	7/23	0/0	0/0	4/20	19/40	0/0	0/0
Mycelis muralis	5/50	6.7/75	10/77	5.6/61	1/23.5	3.8/33	**21/86.7**	**7.4/80**	0/0
Oxalis acetosella	0/0	0/0	**17/85**	1.3/9	0.3/9	0/0	3.4/6.7	0/0	0/0
Physospermum cornubiense	**19.5/100**	**11/75**	0.4/8	1/8.7	2/17.6	9/67	0.4/6.6	0/0	6/83
Pinus nigra	0/0	0.2/8.3	0/0	0/0	0.4/6	0/0	8/20	**58/100**	0/0
Pinus sylvestris	0/0	0.1/8	8/30	0.1/4	2/18	18/40	**72/100**	33/60	0/0
Quercus cerris	2.5/50	0.4/8.3	0/0	0/0	0/0	12/33	2/40	**22/100**	**54/100**
Rosa canina	3/38	7/42	0.8/15	0.7/13	0.6/12	**20/100**	**32/100**	**26/80**	**14/33**
Senecio nemorensis L.	0.6/13	0.8/17	5/54	2.4/48	0/0	1.7/27	**5.6/87**	1/20	0/0
Silene italica (L.) Pers.	0/0	0/0	0/0	0/0	0/0	0/0	0.3/6.6	**4/80**	**5/83**
Sorbus torminalis (L.) Crantz	0.6/12.5	0/0	0/0	0/0	0/0	0/0	0/0	**7.4/100**	**3/33**
Veronica officinalis	0/0	0.4/8	1/15.4	4/26	1/23.5	1/13	**7/73**	3/40	0/0
Viburnum lantana L.	**2.8/75**	0/0	0/0	0/0	0/0	0.4/13	4/27	6/60	9/50
Diversity									
Mean number of alien species per 0.1 ha	0.50±0.27	0.92±0.29	1.62±0.57	1.17±0.17	0.47±0.17	2.73±0.44	4.40±0.58	7.40±1.54	2.33±0.80
Mean number rare, protected and endemic species per 0.1 ha	-	-	0.08±0.08	-	-	-	-	-	-
Mean species number per 0.1 ha	36±1.9	24.8±2.5	34.3±4.4	20.8±1.5	10.4±1.0	36.3±2.6	44.4±3.1	57.2±7.3	45.5±5.6
Mean species number per 1 m^2	4.12±0.64	2.49±0.45	4.58±0.71	2.09±0.26	1.70±0.26	4.74±0.83	5.61±0.63	6.25±0.94	7.87±1.56
Heterogeneity – N_2	10.40±1.58	5.93±0.92	11.65±2.07	4.75±0.47	2.56±0.23	13.21±1.75	18.54±1.80	24.81±2.76	18.67±2.38
Evenness – E'	0.54±0.05	0.51±0.02	0.60±0.03	0.51±0.01	0.62±0.02	0.60±0.03	0.67±0.02	0.68±0.01	0.67±0.03
Homotoneity	70.5	62.0	60.0	58.9	52.3	61.1	62.5	67.5	57.9

[a] – Mean Importance Value; [b] – Frequency, %; * – With **Bold** are noted Importance Values and Frequencies of indicator species for the corresponding communities;

** – With **Bold** are noted species, which are used for community names. ***E'*** – mean evenness index of Hill (1973); $\boldsymbol{N_2}$ – mean heterogeneity index of Hill (1973).

paria. Shrubs and herbs are exceptionally poorly represented. Despite that, in the shrub stratum are more frequent species like *Juniperus communis* L. and *Rubus idaeus*, and in the herb layer species like *Poa nemoralis* L., *Viola riviniana, Lamiastrum galeobdolon, Cruciata glabra, Mycelis muralis, Aremonia agrimonoides, Euphorbia amygdaloides* L., *Cardamine bulbifera* (L.) Crantz, *Helleborus odorus, Galium odoratum, Veronica officinalis* L. and *Vaccinium myrtillus* L. Species richness here is one of the least. Similarly, diversity and evenness are very low.

Fagus sylvatica-Festuca drymeja (*n*=17). This community type is distributed at mean elevation of 1332±20.7 m. Slope expositions are highly variable, but north, west and northwest facing slopes prevail. The habitats are submesic with mostly flat steep slope surface, or occasionally convex. Canopy closure here is highest among all forest communities. Together with *Fagus sylvatica,* species with great importance are like *Pinus sylvestris, Populus tremula, Pinus nigra* and *Prunus cerasifera*. The shrubs are almost lacking. Most important species are *Vaccinium myrtillus*, *Rosa canina* and *Juniperus communis*. The herbs are also poorly represented. With the highest importance are *Luzula luzuloides, Cardamine bulbifera, Hieracium murorum agg L., Poa nemoralis, Lamiastrum galeobdolon, Festuca heterophylla* Lam., *Cruciata glabra, Calamagrostis arundinacea* (L.) Roth and *Luzula sylvatica* (Hudson) Gaudin. Species richness is extremely low at the two scales of measurement. Diversity index is also very low. However, evenness here is highest among all beech communities.

Fagus sylvatica-Corylus avellana-Brachypodium pinnatum (*n*=15). These forests are distributed at mean elevation of 1310±40.6 m, on subxeric or, more rarely, on xeric, southeast and west facing steep slopes with flat and convex surface. Besides *Fagus sylvatica*, other important trees are *Pinus sylvestris, Quercus cerris, Prunus cerasifera, Quercus petraea, Crataegus monogyna* and *Carpinus betulus*. Shrub and herb strata are well developed. Among the shrubs dominate *Rosa canina, Juniperus communis, Rubus idaeus, Lonicera xylosteum* and *Cornus mas*. Herb layer is dominated by species like *Cruciata glabra, Pteridium aquilinum* (L.) Kuhn, *Poa nemoralis, Viola riviniana, Helleborus odorus, Fragaria vesca, Dactylis glomerata* and *Aremonia agrimonoides*. The higher species richness is due to the greater number of herbs. Species diversity is greatest among all beech communities and evenness is among the highest too.

Pinus sylvestris-Fragaria vesca (*n*=15). This community type is formed at mean elevation of 1304±29.0 m, mainly in subxeric or, more rarely, in submesic habitats with southeastern or southwestern exposition and flat gentler slope surface. Tree canopy closure is relatively low. Together with *Pinus sylvestris,* here dominate trees like *Fagus sylvatica, Prunus cerasifera, Pinus nigra, Sorbus aucuparia* and *Picea abies*. Shrub and herb strata are well developed. Among the shrubs prevail species like *Rosa canina, Corylus avellana, Juniperus communis, Rubus idaeus* and *Evonymus europaeus* L. Among the herbs dominant are species like *Mycelis muralis, Poa nemoralis, Aremonia agrimonoides, Geranium robertianum* L., *Brachypodium pinnatum* (L.) P. Beauv., *Calamagrostis arundinacea* and *Viola riviniana*. Herb cover in these plantations reaches its maximum among all forests in the region. Species richness at the two scales is relatively high. The evenness of these forests is very high. The same applies to diversity index.

Pinus nigra-Crataegus monogyna (*n*=5). These conifer communities are distributed at lower mean elevation of 989±24.3 m in submesic habitats on flat gentler slopes, mainly with northern and western exposition. Tree canopy closure is lowest among all described forests. Other important trees are *Pinus sylvestris, Fagus sylvatica, Quercus petraea, Quercus cerris, Carpinus betulus, Prunus cerasifera, Quercus frainetto* Ten.*, Fraxinus ornus, Pyrus pyraster* Burgsd. and *Populus tremula.* Despite the relatively open canopy, shrub and herb cover is lesser. Dominant shrubs are *Rosa canina, Corylus avellana, Prunus spinosa* L. and *Ligustrum vulgare* L. Herb stratum is dominated by *Dactylis glomerata, Aremonia agrimonoides, Poa nemoralis, Hypericum perforatum* L.*, Euphorbia cyparissias* and *Fragaria vesca*. Species richness is extremely high and reaches its maximum among all forest communities in the studied territory. Diversity and evenness indexes also reach its maxima.

Quercus cerris-Cornus mas (*n*=6). These oak forests are distributed at mean elevation of 1024±18.3 m. The habitats are submesic or subxeric with southwestern and eastern exposition. Slopes have convex topography and moderate inclination. Mean canopy cover is not very high. Other principal trees are *Carpinus betulus, Quercus petraea, Fraxinus ornus, Crataegus monogyna, Acer campestre, Prunus cerasifera* and *Quercus pubescens* Wild*.* Shrubs and herbs are abundant. Dominant shrubs are *Corylus avellana, Rosa canina, Prunus spinosa, Chamaecytisus hirsutus* (L.) Link, *Cornus sanguineum* and *Viburnum lantana.* Main herbs are *Helleborus odorus, Dactylis glomerata, Poa nemoralis, Brachypodium pinnatum, Carex montana* L.*, Aremonia agrimonoides, Viola hirta* L. and *Festuca heterophylla*. Mean species richness is very high. Mean diversity and evenness values are also high, comparable to *Pinus sylvestris* communities. The lower elevation and proximity to populated areas of the last two community types expose them to more extensive human influence. These disturbances are mainly livestock grazing, as well as variable forestry activities, such as logging, forest road clearing, etc.

Community Type Comparison

Described community types were tested for significant differences for the main environmental gradients and most important vegetation variables measured by us (Leathwick and Rogers 1996). When variable distribution was not normal, nonparametric Kruskal-Wallis ANOVA on Ranks, Dunn's test was used. In the cases with normal variable distribution, parametric One-Way ANOVA, Holm-Sidak method was employed.

We have found significant differences between the community types for almost all environmental gradients, except one (Figure 2). Beech forests, together with *Pinus sylvestris-Fragaria vesca* community, are found on significantly higher elevation. Differences by this gradient are most pronounced, especially between mixed oak forest and *Pinus nigra* community (Figure 2a). We have also found significant differences relative to other two main environmental gradients – moisture index and slope inclination. Generally, beech forests are distributed on steepest slopes (Figure 2c) and in more mesic habitats (Figure 2b). Slope topography (convexity)

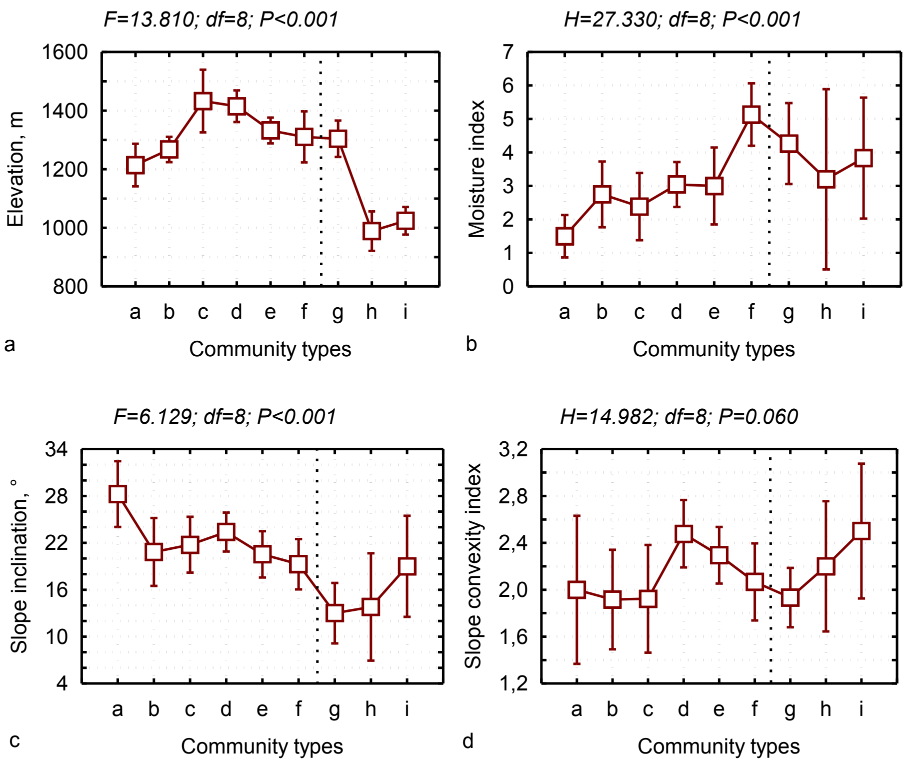

Fig. 2. Community type comparison by the main environmental gradients.

Mean value ± 0.95 confidence interval for all forest communities are shown. Means, which whiskers do not overlap, are significantly different. a) Mean elevation; b) Mean moisture index – higher values mean more xeric conditions; c) Mean slope inclination; d) Mean convexity index. Punctuated vertical line separates beech forests from the other communities. For the full community names see Table 1 and the text. *H* value shows the result from Dunn's test (Kruskal-Wallis ANOVA on Ranks) on the hypothesis that there is not statistically significant difference between tested communities. *F* value shows the test result on the same hypothesis using One Way ANOVA, (Holm-Sidak method).

cannot be used as reliable variable for forest community discrimination in the studied territory (Figure 2d).

Forest communities are compared by the mean cover of tree, shrub and herb strata (Figure 3).

Significant differences were found among them in the cover of all three vegetation layers. Beech communities have higher canopy closure, compared to the other groups, except *Fagus sylvatica-Corylus avellana-Brachypodium pinnatum* community, standing closer to the mixed forests (Figure 3a). Differences among the forest communities were weaker in shrub layer coverage (Figure 3b). Shrub cover is greater in oak and coniferous forests as well as *Fagus sylvatica-Corylus*

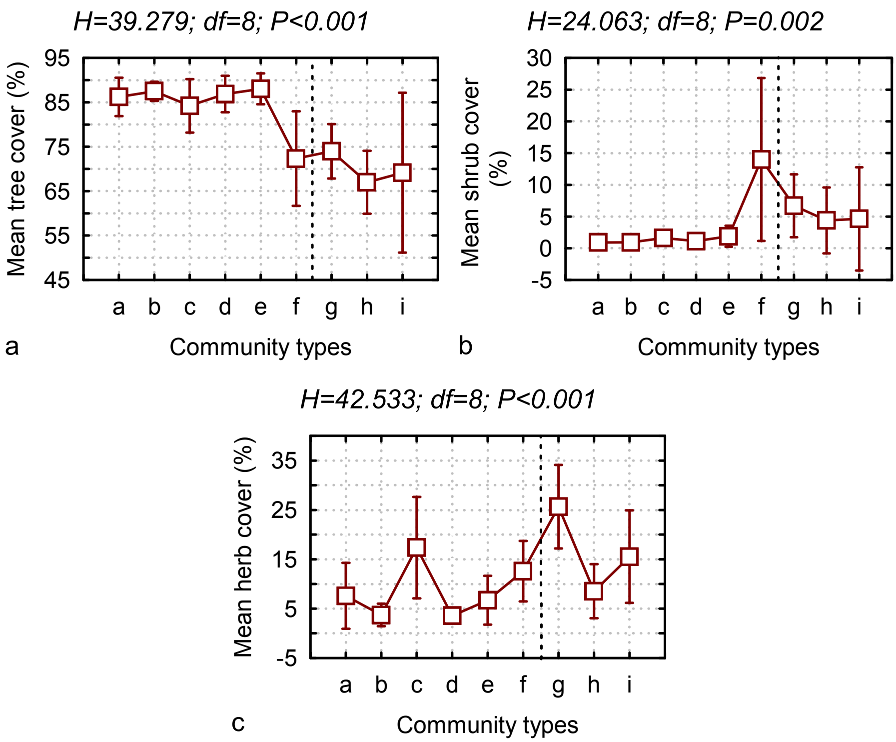

Fig. 3. Community type comparison by vegetation strata coverage.

Mean value ± 0.95 confidence interval for all forest communities are shown. Means, which whiskers do not overlap, are significantly different. a) Mean cover of tree stratum per 0.1 ha; b) Mean cover of shrub stratum per 100 m^2; c) Mean cover of herb stratum per 1 m^2. Punctuated vertical line separates beech forests from the other communities. *H* value shows the result from Dunn's test (Kruskal-Wallis ANOVA on Ranks) on the hypothesis that there is not statistically significant difference between tested communities.

avellana-Brachypodium pinnatum community. Herb layer is most abundant in *Fagus sylvatica-Galium odoratum* and *Pinus sylvestris-Fragaria vesca* (Figure 3c), but not significantly higher, compared to most forest communities.

We compared forest communities by the life form number per 0.1 ha (Figure 4).

Phanerophytes are more numerous in the mixed forests. Again, *Fagus sylvatica-Corylus avellana-Brachypodium pinnatum* community is closer to the mixed forest communities than to other beech forests (Figure 4a). Chamaephytes are least numerous in the studied forests among all life form groups, but they have significantly higher numbers in mixed forests than the beech communities (Figure 4b). The same is the situation with hemicryptophytes and therophytes (Figure 4c, Figure 4e). The opposite holds for the cryptophyte group (Figure 4d). Mesic and submesic beech forests have more cryptophytes than subxeric beech and mixed communities.

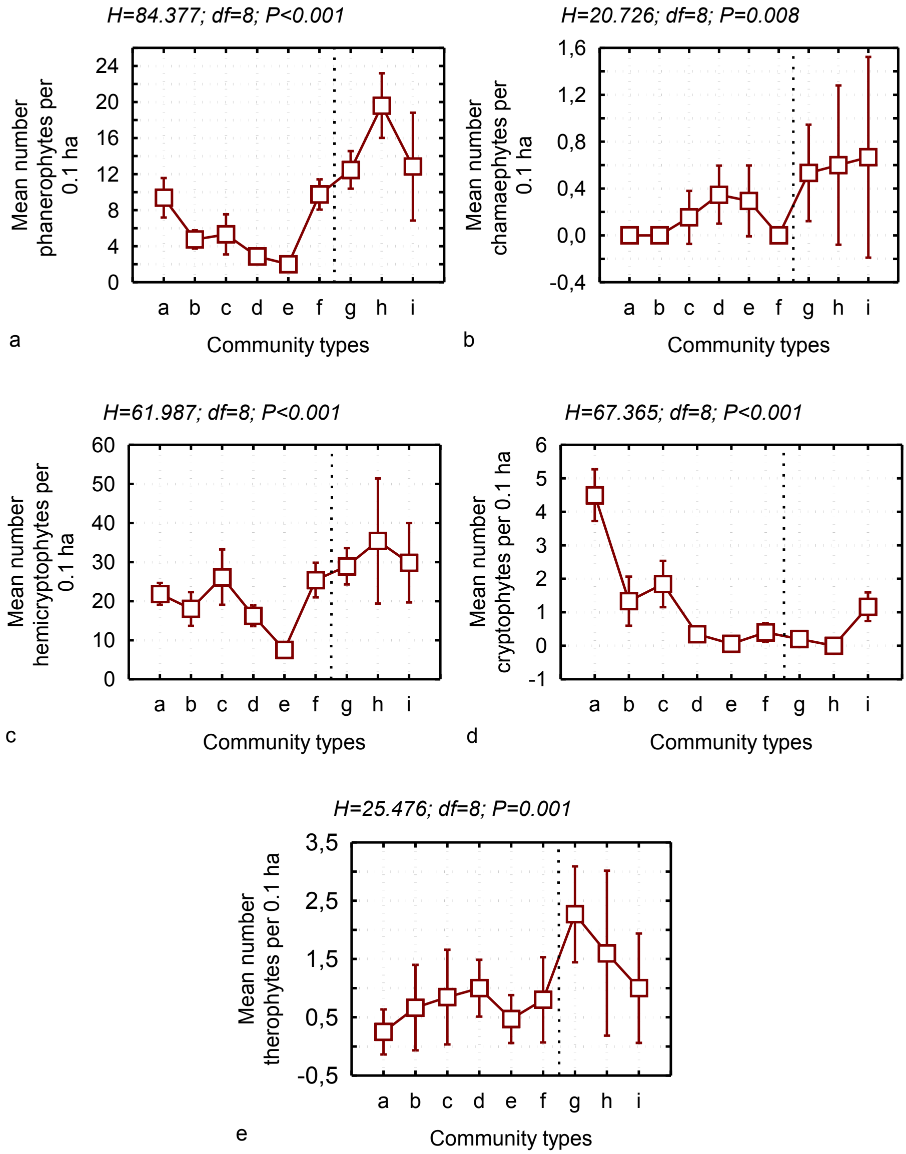

Fig. 4. Community type comparison by life form number per 0.1 ha.

Mean value ± 0.95 confidence interval for all forest communities are shown. Means, which whiskers do not overlap, are significantly different. a) Mean number of phanerophytes per 0.1 ha; b) Mean number of chamaephytes per 0.1 ha; c) Mean number of hemicryptophytes per 0.1 ha; d) Mean number of cryptophytes per 0.1 ha; e) Mean number of therophytes per 0.1 ha. Punctuated vertical line separates beech forests from other communities. *H* value shows the result from Dunn's test (Kruskal-Wallis ANOVA on Ranks) on the hypothesis that there is not statistically significant difference between tested communities.

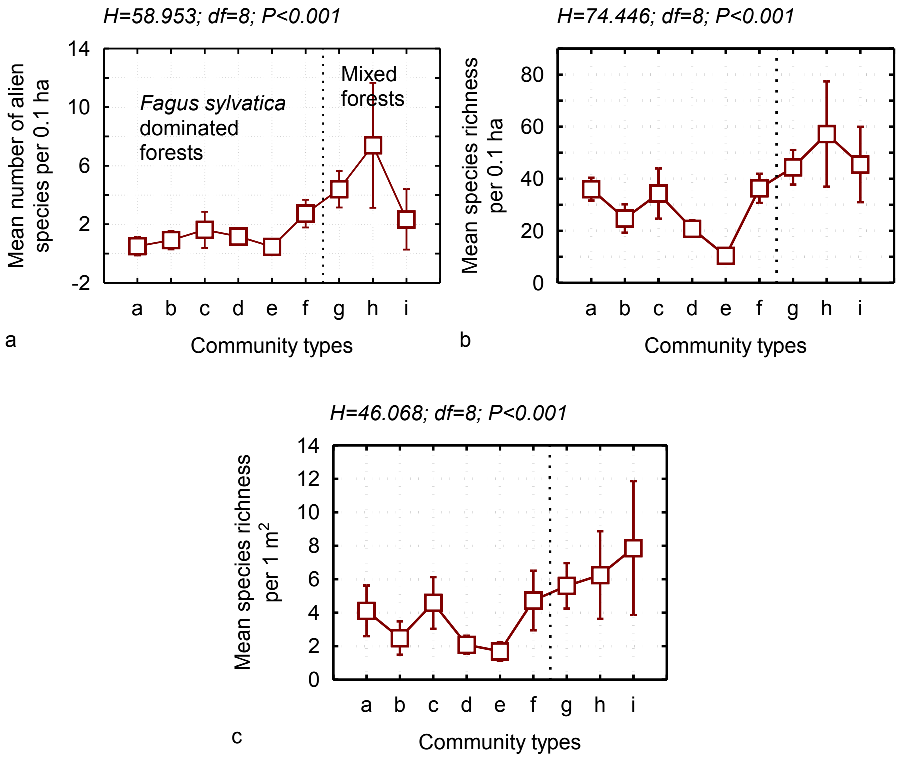

Fig. 5. Community type comparison by alien species number and species richness at the two scales of measurement.

Mean value ± 0.95 confidence interval for all forest communities are shown. Means, which whiskers do not overlap, are significantly different. a) Mean number of alien species per 0.1 ha; b) Mean species richness per 0.1 ha; c) Mean species richness per 1 m^2. Punctuated vertical line separates beech forests from other communities. *H* value shows the result from Dunn's test (Kruskal-Wallis ANOVA on Ranks) on the hypothesis that there is not statistically significant difference between tested communities.

The last comparison of forest communities is by alien species (sensu Richardson et al. 2000) and species richness at the two scales of measurement (Figure 5).

Mixed forest communities and coniferous plantations are more saturated with alien species (Figure 5a). Here, the most xeric *Fagus* community again stands closer to the mixed communities than to the other beech forests. The higher alien species richness of the oak and coniferous communities is probably due to their close proximity to populated areas in the region and to severe disturbance regime there, resulting mainly from human activity, like livestock grazing and logging.

Species richness at the two scales in the mixed oak forests and coniferous communities is also higher (Figure 5b and Figure 5c). Poorer on species are beech communities in submesic habitats (*Fagus sylvatica-Festuca drymeja* and *Fagus syl-*

vatica-Luzula luzuloides), except *Fagus sylvatica-Corylus avellana-Brachypodium pinnatum* community, which is closer to mesic beech forests. *Pinus nigra* community has higher species richness at 0.1 ha, but the oak forest is richest at the 1 m^2 scale. However, significantly lower species richness compared to most other communities is found only in *Fagus sylvatica-Luzula luzuloides* and *Fagus sylvatica-Festuca drymeja* community types.

Discussion

This study aimed classifying vegetation cover of the studied area in more objective and adequate numerical fashion. Testing the consistency of the obtained community types for a number of important vegetation variables and environmental gradients, we tried to reject the hypothesis that vegetation is organized as recognizable community units in the environmental space.

Most of the forest communities, described in this study, are dominated by *Fagus sylvatica*. Literature data, concerning classification of the other types are scarce. Therefore, the following discussion is focused mainly on the beech forests.

Dzwonko and Loster (2000) found clearly expressed geographical gradient in the beech forest floristic composition from southeastern Serbia, through Macedonia, to central Greece. Bergmeier and Dimopoulos (2001) distinguish the following beech forest groups in Greece: 1) beech forests in mesotrophic habitats; 2) beech forests in “cool acidic” habitats; 3) beech forests on carbonate places at higher elevation; and 4) beech forests in moderately warm and dry habitats. One of the beech communities from the first ecological group (*Galium odoratum-Fagus sylvatica* with diagnostic species *Galium odoratum, Epilobium montanum, Cardamine bulbifera*) coincide by name with our type *Fagus sylvatica-Galium odoratum* (with indicator species *Galium odoratum, Athyrium filix-femina, Lamiastrum galeobdolon* and *Oxalis acetosella*). However, we placed our community type in the group of submesic beech forests. Unfortunately, Bergmeier and Dimopoulos (2001) did not give quantitative data, on which basis, detailed comparison to be made. According to the authors, community differentiation follows complex “edaphic-climatic-phytogeographic” pattern of distribution. In their general physiognomy, the beech communities studied by them, resemble the Central European beech forests (Bergmeier and Dimopoulos 2001). However, our results point that the main environmental gradients, responsible for beech forest pattern in the studied territory are elevation and moisture gradients. Here should be noted that the scale of the two studies is different. Ours is more local. Despite that, Bergmeier and Dimopoulos (2001) did not publish detailed data for the species richness our results confirm their conclusion that the beech forests are generally poorer on plant species.

Tzonev et al. (2006) made classification scheme of the beech communities covering the entire territory of Bulgaria. They described altogether 12 community types dominated by *Fagus sylvatica*. The authors found environmental and geographic continuum of the described communities. Community arrangement, according to them, expresses the “geographical structured effects of the ecological factors, which change from west to east, as well as from west to northeast”. Three community types coincide by name with our groups.

These are *Fagus sylvatica-Galium odoratum*, *Fagus sylvatica-Luzula luzuloides* and *Fagus sylvatica-Festuca drymeja*. According to Tzonev et al. (2006), *Fagus sylvatica-Galium odoratum* is characterized with poor species composition and lower herb layer cover. This is in contradiction with our results, showing that this community type had richest species composition and greatest herb cover among all beech forests described in our study. We also contradict Tzonev et al.'s (2006) results relative to *Fagus sylvatica-Festuca drymeja* community type. According to them, this group is found on moist shady slopes, which they judge by the presence of some hygrophilous plant species like *Eupatorium cannabinum* L. and *Prunella vulgaris* L. On the contrary, our results show that this community type occupies relatively dry habitats. Therefore it is placed in the group of subxeric beech forests (see Table 1 and Figure 2b).

Our results support Tzonev et al.'s (2006), relative to the third community type (*Fagus sylvatica-Luzula luzuloides*), and particularly the conclusion that this is relatively poor on species forest community. It has already been mentioned that the lack of detailed quantitative data in the phytosociological studies, like Tzonev et al.'s (2006), resulting in inability for statistical tests and difficult comparison possibility.

Tzonev et al. (2006) made the conclusion that Bulgarian beech forests differentiate depending on soil, local topographic and climatic gradients, resembling the Central European beech communities. Unfortunately, they did not support this conclusion with enough data in their paper. However, on the ground of our results, we are inclined to agree with this conclusion.

In South Rhodopes (Northeast Greece) pure and mixed beech forests have been investigated with multivariate methods (Tsiripidis et al. 2007a). The authors classify studied communities in 12 "vegetation units", placing them in four ecological groups: mesophilous, acidophilous, calcareous, and thermophilous beech forests. Vegetation unit arrangement expressed the complex gradient from moist, rich and shady habitats toward dry, poor and warm ones (Tsiripidis et al. 2007a). One community type from the mesophilous group (*Fagus sylvatica-Galium odoratum*) coincides by name with one of our types. According to Tsiripidis et al. (2007a), these forests are formed on relatively higher elevation, mainly on convex slopes. They also were characterized with greater stand height. Principally, we agree with the latest conclusions, but these forests on the Vitosha Mountain south slope are distributed mainly on concave or flat slopes.

We have found similarity between most of the Tsiripidis et al.'s (2007a) *Calamagrostis arundinacea-Fagus sylvatica* type variants from the acidophilous group and our subxeric beech forest. The latter are distributed in poorer and dryer habitats at mean elevation of around 1300 m. They occupy slopes with steeper or less steep inclination, mainly on flat, or rarely, on convex slopes, which most often represent successional vegetation.

Similarity has been found also between one community type (*Brachypodium pinnatum-Fagus sylvatica*) from the Tsiripidis et al.'s (2007a) calcareous group and our *Fagus sylvatica-Corylus avellana-Brachypodium pinnatum* community type from the subxeric forest group.

Tsiripidis et al. (2007a) conclude that floristic differentiation of the Rhodope beech forests, resulting from the meso- and microclimatic (caused mainly from elevation differences), and soil (nutrient content and N) factors. Our considerations point that these factors are also the reason for vegetation pattern formation on the territory of the current study, resulting not only from elevation differences and soil characteristics, but from the moisture gradient influence as well.

The role of geographical and ecological factors for the floristic differentiation of beech forests in Greece has been investigated (Tsiripidis et al. 2007b). Classification resulted in 14 groups of beech forests, distributed in northeastern and central parts of the country. Two of them are identical by name with our *Fagus sylvatica-Brachypodium pinnatum* and *Fagus sylvatica-Galium odoratum* community types. Discussing their results, Tsiripidis et al. (2007b) conclude that presented classification reflects the ecological and geographical gradients. They also comment that the results from such studies depend on the size of the studied territory, its position along assumed regional gradient, as well as on the capacity and quality of the data used. This is a statement that we share, but once again, according to our results, leading gradients, shaping the vegetation pattern in a relatively localized territory, are habitat moisture and elevation.

Community concept, considering them as actually existing units, composed of coexisting species, is applicable only within the boundaries of a specific territory, together with its complex of environmental gradients, i.e. plant community is a landscape phenomenon (Austin 2005). Our results show that beech communities are almost indistinguishable by the most variables tested, except *Fagus sylvatica-Corylus avellana-Brachypodium pinnatum*, which is closer to the mixed forest. Greater variance among the mixed forest communities for the most variables has also been found. Despite the statistical differences between the beech and mixed forests, we consider plant communities as segments or sections in the species population cenocline, indiscernible in the ecological space, but only in the landscape; therefore their limited usefulness in vegetation theory improvement. Moreover, we recognize that classification studies for practical purposes should be completely quantitative with statistical testing of described community types. Merely qualitative investigations are better being abandoned in future.

Plant community concept is preferable in the environmental management, given the condition that intended managerial activities are applied on a previously clearly defined area (Austin 2005). In conclusion, in the context of Austin's (2005) conclusion, we generalize that the presented classification is useful from practical view point, concerning different activities (for example, forestry or conservation measures), which affect parts of the studied territory, but it has limited capability in the improvement of the vegetation theory.

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NEST PREDATION OF CHUKAR PARTRIDGE (*ALECTORIS CHUKAR* GRAY, 1830) IN SOUTHEASTERN BULGARIA: EXPERIMENTAL STUDY

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Abstract

This study aims investigation of chukar partridge losses during the incubation period in species' nesting habitat. From 45 nests set in 2010 and 2011, 19 (42.22 %) were destroyed. In 13 of these, mammal predation was the cause. 4 (8.89 %) were destroyed by birds and 2 (4.44 %) by unknown pest. Statistical differences between the size of destroyed nests and herb vegetation height have not been found. Losses were, more likely, distributed randomly in time. Relationship between setting time and herb vegetation height was not established.

Key words: chukar partridge, nest predation, nest losses.

Introduction

During the last decade chukar partridge remained a species with low numbers in Bulgaria. Its numbers continue to decline. According to the latest data it reaches approximately 1500–3000 (Birdlife Internatinal 2004) or 2000–3000 (Nankinov et al. 2004) pairs.

Bird's reproductive failure is caused mainly by nest predation (Ricklefs 1969), which can influence its population numbers (Martin 1988a, 1988b; Fuller et al. 1995), as well as their choice of nesting habitat (Martin 1988c, Hatchwell et al. 1996, Martin and Roper 1988, Muller 1989, Berg 1992). Moreover, it can affect population's spatial dynamics and become an important factor for predator numbers (Fuller et al. 1995, Robinson et al. 1995). Birds nesting on the forest floor are affected more frequently by predatory birds than mammals (Angelstam 1986). Nesting predation of red-legged partridge *Alectoris rufa* (Linnaeus, 1758) decreases with the increasing height of vegetation cover (Rands 1988).

This study aims establishing of chukar partridge losses during the incubation period in the birds' nesting habitat.

Material and Methods

The current study was conducted during July 2010 and from late April to late June, 2011, in typical chukar partridge habitat near Harmanli Town (Table 1).

According to their geographical location studied areas fall in the lower parts of the Thracian valley and Sakar Mountain. Studied habitat is dominated by herb and shrub vegetation. At some places outcrops can also be found. Principal shrub species is *Paliurus spina-christi* Mill., having variable cover and 1–3.5 m height. Tree vegetation is composed of sprouting oak forests along the ravines and fruiting tree species in some parts of the studied territory. There are cultivated areas, represented mainly by cereal crops, orchards, vegetable crops and vineyards. Some territories are pastures and others are fallow lands. At the end of April and the beginning of May the vegetation is short and studied habitats are more open. *Paliurus spina-christi* is still leafless. In the middle of May herb vegetation is lush and gradually embraces the shrub bases. Chukar partridge nests, built in these places, are more concealed, which presumes lesser losses. In the end of June, vegetation dries up and the habitat becomes barer. However, dried vegetation continues to secure a good cover, especially in places where grazing of livestock is lacking. The influence of vegetation cover height on nest predation was estimated by division of nest losses in three time periods: 1 – from April 24 to May 15, 2011; 2 – from May 15 to June 20, 2011; and 3 – from July 2 to August 3, 2010.

Aiming to account the advancing change of vegetation cover and habitat heterogeneity 45 chukar partridge nest

Table 1. Nest numbers, locality and observation periods.

Nest loss estimation period	Coordinates of set nests	Number of set nests
April 24 – May 21	N 41º 58′ E 25º 59′	5
	N 41º 56 E 25º 56′	5
	N 41º 56 E 25º 50′	11
May 22 – June 20	N 41º 54 E 25º 54′	8
	N41º 54 E 25º 55′	9
July 2 – August 3	N 41º 56 E 25º 56′	3
	N 41º 56 E 25º 50′	4

were located in different parts of its preferred habitat (Table 2).

Loss causes were specified, using chukar partridge model eggs. The model egg was made of farm egg by draining it contents through couple of openings, and then filling it with plaster. Before plaster hardening, through the openings, plastic cord (Hyper carp Brown 0.40 mm), bearing stretch of 22.5 kg, was set. Each nest contained eight eggs. The eggs were put directly on the ground in shallow pit covered with sand (30 cm diameter) enabling

Table 2. Set nest location according to habitat type.

Habitat type	*Paliurus spina-christi* shrub	Other shrubs, *Rosa* and *Prunus* genera	Outcrops	Hedgerows	Vineyards	Orchards
Number of nests set	26	3	8	3	4	1

bird and mammal track observation. Any nest in which at least one egg was bearing markings of shell disturbance was recognized as destroyed.

Loss cause was determined by the markings left in the egg plaster of the destroyed nest. The nests were checked weekly during the whole 24 day period. Each nest contained random combination of egg colors closely resembling the natural chukar partridge nests. Gathered data were statistically analyzed with Past (Hammer et al. 2001).

Results

From 45 nests, set during the two years of study, totally 19 (42.22 %) were destroyed. In 13 (28.89 %) cases, the cause was predatory mammal, 4 (8.89 %) nests were destroyed by birds, and 2 (4.44 %) were ruined by unknown agent (Table 3).

We have not found significant difference between the destroyed nest numbers in the three study periods (H=0.622; p>0.05). Nest losses caused by mammals are significantly greater than bird-caused

Table 3. Confirmed losses by the checking period.

Loss cause	Mammal, number (%)	Bird, number (%)	Unknown, number (%)	Total loss, number (%)
Set date – April 24	–	–	–	–
First week check	3 (15.8 %)	2 (10.5 %)	0	5 (26.2 %)
Second week check	3 (15.8 %)	0	0	3 (15.8 %)
Third week check	0	0	0	0
Fourth week check	0	1 (5.3 %)	0	1 (5.3 %)
Set date – May 22	–	–	–	–
First week check	1 (5.3 %)	0	0	1 (5.3 %)
Second week check	2 (10.5 %)	1 (5.3 %)	0	3 (15.8 %)
Third week check	1 (5.3 %)	0	1 (5.3 %)	2 (10.5 %)
Fourth week check	0	0	0	0
Set date – June 2	–	–	–	–
First week check	2 (10.5 %)	0	0	2 (10.5 %)
Second week check	1 (5.3 %)	0	0	1 (5.3 %)
Third week check	0	0	1 (5.3 %)	1 (5.3 %)
Fourth week check	0	0	0	0
Total loss	13 (68.5 %)	4 (21.1 %)	2 (10.6 %)	19 (100 %)

and than that with unknown cause (χ^2 = 10.848; p<0.01). Five nests were destroyed by canids (Canidae), six by mustelids (Mustelidae), and two nests by unknown mammal species. Canid representatives were domestic dog *Canis familiaris* (Linnaeus, 1758) – one nest; golden jackal *Canis aureus* (Linnaeus, 1758) – one nest; and red fox *Vulpes vulpes* (Linnaeus, 1758) – two nests. In one case, the canid pest was not known. In two cases, the nests were destroyed by Stone marten *Martes foina* (Erxleben, 1777). One was damaged by European polecat *Mustela putorius* (Linnaeus, 1758). Three nests were harmed by unidentified mustelid species. There was not specific mammalian group which destroyed significantly greater nests than the other groups (χ^2 = 2.001; p>0.05). There was no significant difference between the ruined nests in the first two and the second two weeks (χ^2 =0.474; p>0.05). We have not found significant differences between the destroyed nests' size and the vegetation height (χ^2 =1.369; p>0.05). Losses are rather randomly distributed temporarily without any relationship according to setting time and vegetation height.

In two cases the cause of nest destruction was not determined. One of the nests was destroyed before flood rain (June 20, 2011) and traces were lacking. In the second case, there was narrow trail leading toward the nest, with snake traces in the sand, but it cannot be claimed that this was the cause for the missing eggs (July 22, 2010). Snakes were reported as chukar partridge nest pests in the United States (Christensen 1970). It has been observed a snake density increase during the egg-laying period around chukar partridge farm near to Sliven Town (Mikhailov, unpublished). In the current study, confirmed cases of snake-destroyed nests are lacking.

Discussion

Our results show that chukar partridge nest losses in the studied area are caused mainly by predatory mammals (28.89 %). Among the canids potential pests are species like red fox, golden jackal and domestic dog. At the places with livestock grazing accompanying shepherd dogs caused increase of chukar partridge nest losses. Mustelids can destroy the nests too, but in specific habitats, according to their own distribution pattern. According to Chesness et al. (1968), nest predation of pheasant *Phasianus colchicus* (Linnaeus, 1758) is mainly due to polecats and crows. In our study, nests destroyed by birds are significantly lesser than those ruined by mammals. This is probably due to the low bird densities which are potential nest pests. During the field observation of the studied territory single jays *Garrulus glandarius* (Linnaeus, 1758) were noticed. Predatory rate is related to corvid bird abundance. Their density in turn correlates with the extent of agricultural land and human population density, as well as forest fragmentation (Andrèn et al. 1985). Chukar partridge habitats are characterized with the restricted agricultural lands. This determines the lower density of corvid birds there. Therefore, the lesser nest losses in these areas. Corvid birds destroy mainly nests constructed on shrubs, while predatory mammals usually ruin ground nests (Söderstrom et al. 1998). Nest predation of red-legged partridge, occupying olive orchards in Spain, is due mainly to dogs and cats

(Duarte and Vargas 2001). We have not found significant differences between the destroyed nest size and the vegetation height. According to other studies, predation extent is not always associated with the degree of nest concealing (Howlett and Stutchbury 1996, Burhans and Thompson 1998, Braden 1999). This is probably due to non-visual nest searching mode of some predators (Rangen et al. 1999). They can also use the opportunity of finding the parents (Götmark et al. 1995, Cresswell 1997, King et al. 1999). However, other studies show that predation rate in red-legged partridge (*Alectoris rufa*) decreases with the vegetation height increase (Rands 1988). Higher vegetation cover and heterogeneity can reduce the predation percentage (Newton 1998, Willson et al. 2001). Nest predation rate of ground-nesting birds is different in the variable habitats. It depends on predatory mammalian density (Picman 1988). Other chukar partridge habitats, where predator type and density are different, will probably have different extent of destroyed nest compared to our results. There are several specifics associated with our experimental set. It was not clear whether the set nest density in the studied habitats was not too higher. If this was the case, it could lead to higher losses compared to natural populations. Our experimental model does not account the parent birds' presence in the nests. According to Skutch (1949), Willis (1973), Cottfried and Thompson (1978) in Picman (1988), parent presence on the nest or in close proximity to it can attract predators. Therefore, our estimation of predatory rate is probably reduced. Unfortunately, there is lack of data about the chukar partridge reproductive success in Bulgaria. Therefore, our results reflect the relative differences of species' nest predation.

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APPROPRIATE TREE SPECIES FOR INTENSIVE FOREST PLANTATIONS IN CENTRAL NORTHERN BULGARIA

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Abstract

The ever-growing demand for timber and restricted harvesting in oak and beech forests resulted in the idea of establishment of fast-growing forest tree plantations. The present paper presents results of a study on the plantations established in 1984 and 1985 in State Forest Service (SFS) Gorna Oryahovitsa, near the village Paisiy. The experiment consisted of pure plantations of *Pseudotsuga menziesii* (Mirb.) Franco, *Cedrus atlantica* Manetti, *Quercus rubra* L., *Tilia tomentosa* Moench., *Robinia pseudoacacia* L. and *Pinus nigra* Arn., and mixed plantations of *Cedrus atlantica*, *Quercus rubra* and *Tilia tomentosa*. All species were planted in three different locations. *Robinia pseudoacacia* plantations with initial density 2 x 1 m, and natural *Quercus cerris – Q. frainetto* stand were used as control. The intensive plantations were more productive than both conventional stands and natural forest. At the age of 20 to 21 the target species were in good health, grew well, and did not show any signs of deteriorating health. Highest increment was recorded in the pure plantations of *Tilia tomentosa*, *Pseudotsuga menziesii* and *Pinus nigra*. The research proved that intensive forest plantations are especially suitable for the lower forest belt if they are planted on suitable locations and the soil is appropriately cultivated.

Key words: growth, initial density, intensive plantations, increment.

Introduction

The ever-growing demand for timber and the intensive deforestation of woodland on a national and global scale needs efficient solutions of this problem. The exploitation of high-stem oak and beech forests, as well as forests of other valuable species, should be restricted. The possibilities for establishment of fast-growing polar plantations are limited due to the few available areas suitable for this purpose. In the 1970s scientists came up with the idea of establishment of industrial plantations of fast-growing tree species in the lowland forest zone. This, through intensive cultivation, would provide production of small, medium-sized and some large-sized logs for a period of 25 to 30 years. In 1973 the Government decreed that the Ministry of Forestry should establish a total area of 150,000 hectares of intensive plantations – 90,000 ha in North Bulgaria and 60,000 ha in South Bulgaria.

Possibilities for establishing forest plantations for accelerated timber production at early age were studied among others by Broshtilova et al. (1988), Kostov et al. (1988), Taris (1987), Tsanov et al. (1990, 1992), Broshtilov et al. (2003), Broshtilov and Broshtilova (2007a,b), Kalmukov (2007), and Popov (2009).

The present paper attempts to analyze and assess the results derived from the established intensive plantations for the accelerated production of deciduous and conifer timber in the lowland forest zone of Central North Bulgaria.

Material and Methods

Field studies began in the vicinity of the village of Paisiy in 1982. Indigenous forest of Turkey oak (*Quercus cerris* L.) and Pubescent oak (*Quercus pubescens* Willd.) has been cut and part of the stand uprooted. Complete soil preparation was performed. In the spring of 1984 the first plantations were established: pure plantations of *Pseudotsuga menziesii* with row widths of 2.4 and 3.6 m and four planting densities – 1.2, 1.8, 2.4 and 3.6 m. Each plot was 0.1 ha and the plantations were established in three different locations. The other plantations were: pure plantations of *Quercus rubra* with initial density of 2.4 x 1.2 m and 3.6 x 1.8 m; a pure plantation of *Tilia tomentosa*, with initial density of 2.4 x 1.2 m; and a cultivar-selection experiment with 14 clones of *Robinia pseudoacacia* with initial planting density 4 x 4 m. In 1985, a pure plantation of *Cedrus atlantica* was established with the same row widths and densities as in plantations of *Pseudotsuga menziesii.* Mixed plantations of *Cedrus atlantica* and *Quercus rubra* and *Tilia tomentosa*, varied sequentially at every other row with initial planting density of 3.6 x 1.8 m were also established. The cultivar-selection experiment with *Robinia pseudoacacia* L. was extended with 14 more clones. The plantations of *Pseudotsuga menziesii* were planted using 2-year-old saplings, while the plantations of *Quercus rubra* and *Tilia tomentosa* were planted using 1-year-old saplings. The cultivar-selection experiment with *Robinia pseudoacacia* L. was established with one-year-old vegetative saplings from root cuttings. After planting the trees were stump-cut and subsequently one shoot was left for each plant. The Cedar plantations were established using 2-year-old saplings of Atlantic and Himalayan cedar (*Cedrus deodara* G. Don). The rows were earthed-up during the first four years, and the inter-row spaces were disc-harrowed three times a year for the first six years.

Measurements were done in 2005. Diameters were measured to nearest 1 cm, and height to nearest 0.5 m. Model trees of Douglas fir, Atlantic cedar, Red oak, Silver lime, and Black locust were extracted for trunk analysis. Results were compared to those of the indigenous Oak forest, local black locust stands, and Austrian Black pine stands.

Results and Discussion

The comparative analyses of stands of approximately the same age and location enabled certain inferences regarding the specific biological characteristics of the species, and the importance of the initial planting density on their status, growth and increment.

The initial planting density had little impact on the degree of tree loss at the age of 21. Self-thinning was affected to a greater extent by the spacing between the saplings within a row, rather than by the spacing between rows. At density

2.4 and 3.6 m, the increase of spacing between the saplings within a row from 1.2 to 3.6 m expressed the same trend of substantial decreasing the number of fallen and dead saplings. At the age of 21, the percentage of viable trees varied from 70 to 91.7 % (Table 1). Obviously, using a spacing of 1.8 m between the saplings resulted in greater number of survived trees. To a certain extent this could be due that at such spacing the crowns close later and individual trees are less affected by competition of surrounding trees than those planted at initial density of 1.2 m. Conversely, when the growth space was more than 2.4 m, any loss could be attributed to rooting failure and damage caused by wild animals. Douglas fir suffered from debarking and stem cutting by stag and deer, which was observed in other introduced species. This damage could not be prevented, even when stands were fenced. There was rarely more than one stem of Douglas fir at a single planting spot. Growth space had stronger impact on the diameter- than on height growth (Table 1).

The stands with greatest number of trees had the smallest average diameter of 14 cm (planting density 2.4 x 1.2 m, 2546 trees·ha^{-1}, with a growth space of 3.93 m^2). The smallest diameter was 5.0 and the greatest one was 23 cm. Trees with trunks below the average diameter were predominant. With the increase of growth space, the average diameter of trees in stands with different initial densities also increased. The greater distance between rows provided better growth conditions. When the growth space was above 7.0 m^2, the diameter growth was affected to a lesser extent. The height growth depended on the initial density to a lesser extent. At 3.6 x 1.8 m planting density the average height was 13.2 m, while at 2.4 x 2.4 m it was 12.9 m. Regardless of the initial density, trees in all stands were in equally good health, with trunks not self-pruned and branches along the whole stem preserved. The initial planting den-

Table 1. Growth and yield of 21-year-old stands of Douglas fir at various initial densities

Planting density, m	No trees planted, ha^{-1}	Live trees, ha^{-1}	Survival, %	Diameter, cm			Height, m		Stock, m^3·ha^{-1} debarked
				Average	Min	Max	Average	max	
2.4 x 1.2	3472	2546	73	14.0	5.0	23.0	13.1	16.1	217.0
2.4 x 1.8	2315	2046	88	15.6	6.0	23.0	13.0	16.0	228.0
2.4 x 2.4	1736	1428	82	18.3	6.0	25.0	12.9	15.6	199.0
2.4 x 3.6	1157	1008	87	19.3	7.0	26.0	12.9	15.4	191.0
3.6 x 1.2	2315	1848	80	16.0	6.0	23.0	13.1	16.1	216.0
3.6 x 1.8	1543	1471	95	17.6	6.0	25.0	13.2	15.6	195.6
3.6 x 2.4	1157	1068	92	20.0	6.0	25.0	12.9	15.4	204.0
3.6 x 3.6	772	743	96	20.3	7.0	28.0	12.9	15.3	138.0

sity has affected only the thickness and length of the branches and the height to which they were withered. The increase of growth space from 2.4 x 1.2 to 3.6 x 3.6 m produced an increase of the percentage of live branches. At the smallest growth space the withered branches were up to 6 or 7 meters, while at the largest growth space they were up to 2 to 4 meters. The volume was dependent on the initial planting density. At planting density 2.4 x 1.2 m debarked volume was 217 $m^3 \cdot ha^{-1}$, and at 3.6 x 3.6 m it was 138 $m^3 \cdot ha^{-1}$, which is relatively high value for this age.

Height growth of the average model tree was most intensive at the age 10 or 11 and the average increment remained high. The diameter growth was most intensive at the age of 13 or 14 in the stands with initial planting density 2.4 x 2.4 m. Although passed the peak, the diameter growth was still intensive. Annual increment values were more than 0.5 cm. Volume growth was intensive and still had not peaked. At the age of 21, Douglas fir trees were still growing intensively with increasing stem volume. The number of withered trees was insignificant – these were trees with a small diameter, considered industrially unimportant. They could be left onsite in order to improve growth conditions. All stands were in good health and unaffected by diseases or pests.

Under the same conditions and initial planting density patterns, Atlantic cedar at the age of 21 displayed less vigorous growth than Douglas fir. The percentage of live trees varied from 50% at 2.4 x 1.2 m planting density to 64% at 3.6 x 1.8 m (Table 2). The degree of self-thinning was also affected by the percentage of Himalayan cedar trees in the stand. The experiment corroborated the opinion that the Himalayan cedar should not be used in North Bulgaria. It is strongly susceptible to shortages of air moisture and low ambient temperatures. The Atlantic cedar showed better adaptability. Another

Table 2. Growth and increment of 20-year-old stands of Atlas cedar planted in the vicinity of the village of Paisiy at various initial densities.

Planting density, m	No trees, ha^{-1}	Live trees, ha^{-1}	Survival, %	Diameter, cm			Height, m		Stock, $m^3 \cdot ha^{-1}$
				average	Min	Max	average	max	
2.4 x 1.2	3472	1737	50	16.3	6.0	25	13.0	15.4	188.81
2.4 x 1.8	2315	1343	58	16.6	7.0	28	13.0	15.2	146.0
2.4 x 2.4	1736	972	56	19.3	7.0	28	12.8	15.0	167.0
2.4 x 3.6	1157	640	55	20.6	8.0	32	12.8	15.0	112.0
3.6 x 1.2	2315	1273	55	17.0	5.0	27	13.0	15.3	145.0
3.6 x 1.8	1543	1033	67	19.5	8.0	31	12.9	15.2	174.0
3.6 x 2.4	1157	822	71	23	7.0	31	12.8	15.0	167.0
3.6 x 3.6	772	361	47	23	13.0	34	12.7	14.9	76.0

cause for greater self-thinning of stands with greater growth space was the damage inflicted by wild animals. At the age of 21 the stand with initial density 2.4 x 1.2 m had 1,737 remaining trees per hectare with growth space of 5.76 m^2 per tree. The stand with greatest initial density of 3.6 x 3.6 m had 361 remaining trees per hectare with growth space of 27.7 m^2, which corresponds to the 3.6 x 7.69 m planting density. The increase in growth space resulted in trees with larger diameters.

The stand with initial density of 2.4 x 1.2 m had an average diameter 16.3 cm, with the largest value being 25 cm. Using the same row spacing but greater spacing between the saplings provided better conditions for diameter growth. At 2.4 x 3.6 m planting density the average diameter was 20.6 cm, with the largest one being 32 cm. The same trend was observed for the stand with a row spacing of 3.6 m – the increase of spacing between the saplings resulted in larger diameters (Table 2). At 3.6 x 1.2 m planting density the average diameter was 17 cm, and at 3.6 x 3.6 m it was 23 cm. The same model was observed for the maximum diameter measured in these stands – it was greatest (34 cm) in the stand with the greatest growth space. At the age of 20 the average height of trees was approximately 12 to 13 m, and the maximum one was 15 to 16 m.

The growing stock depends on the number of trees. It is higher when more trees per hectare are retained. At this age the stock of the stands with highest initial density of 2.4 x 1.2 m was 188.81 $m^3 \cdot ha^{-1}$ debarked, but stems were smaller in size. At 2.4 x 1.8 m planting density the stock was 146 $m^3 \cdot ha^{-1}$, and at 3.6 x 1.2 it was 145 $m^3 \cdot ha^{-1}$, but these trees had larger diameters.

Under the same conditions and at the same age, the number of the remaining Cedar trees in the mixed stands depended on the other species. In the stands with Red oak the remaining cedar trees were 21 % more than the trees in the stands with Silver lime (Table 3). Red oak turned out to be a better companion for the Cedar where survival rate was 63.47 % for the Cedar and 84.59 % for the Red oak. Although rare, some Cedar trees had two stems thus reducing their growth space to 9.03 m^2. The remaining Cedar trees amounted to 554 trees per hectare. Number of trees having two stems was higher in Red oak, thus reducing the growth space from 7.66 m^2 to 5.85 m^2. In the mixed stands of Cedar and Silver lime, less than one half of the planted Cedar saplings survived – 363 trees per hectare.

Approximately 94.95 % of the initial Silver lime trees survived. At the same time the number of stems per tree varied from 1 to 6, or total of 2,522 trees per hectare, which is more than three times the amount of initial saplings. Their growth space had shrunk to 3.97 m^2 per stem. The Red oak had a better influence on the Cedar than did Silver lime. The greater number of remaining trees per hectare affected their diameter growth – more trees had remained but with smaller diameters. The average diameter of Cedar was 18 cm and the largest one – 25 cm. In the mixed stands with Silver lime less trees survived, but their average diameter was larger – 18.5 cm. The stock of the cedar in the stand with Red oak was 60.32 $m^3 \cdot ha^{-1}$ and in the stand with Silver lime it was 39.46 $m^3 \cdot ha^{-1}$. Silver lime had the smallest average diameter – 11.5 cm, but the greater number of stems resulted in a greater volume – 87.00 $m^3 \cdot ha^{-1}$. Higher stock of the mixed stand of red oak and cedar (134.32 $m^3 \cdot ha^{-1}$) was due to the larger Cedar volume (Table 3). The two accompanying species – Red oak and Silver lime – did not have a significant influence on self-pruning of the cedar. Branches were preserved even in the lowest part of the trunks at height 1.0–1.5 m. Up to one-third of the Red oak trunks were self-pruned, while less than one-third of the Silver lime trunks were self-pruned. Red oak and Silver lime trees were fruit-bearing, in good health and still growing in both diameter and height.

At the age of 21 the pure stands of Red oak were self-thinned to a differing extent depending on their initial density. At 2.4 x 1.2 m planting density about 46 % of the initial saplings survived, while at 3.6 x 1.2 m this percentage was 70 %. The greater growth space facilitates survival of more stems. Although rare, there were some cases of two stems in a single planting spot. Greater initial density had a negative impact on the stands and resulted in a greater number of withered trees. Despite the relatively small number of remaining trees, the greater initial planting density had negatively affected their diameter growth. Trees in the denser pattern had smaller average diameter – 13 cm (Table 3). The experiment proved the theory that the Red oak is a light-demanding species prone to phototropism. The larger initial growth space had a positive effect on the number of remaining trees as well as on better growth and increment. The average trunk diameter was 14 cm and the largest one was 19 cm. The growing stock (debarked) was 146 $m^3 \cdot ha^{-1}$. Under the same conditions Silver lime, being less sensitive to light conditions, had more remaining trees per hectare and more stems per planting spot even in the stand with the highest initial density – 2.4 x 1.2 m (Table 3). As larger number of trees remained, this facilitated the self-pruning, but at certain stage of tree development it negatively affected their diameter growth. With an average diameter of the stand 10.5 cm, debarked volume stock of 180.5 $m^3 \cdot ha^{-1}$ and 212 $m^3 \cdot ha^{-1}$ with bark this sylvicultural system seems to be the most productive among all deciduous tree species.

In Black locust the initial planting density and origin of saplings had a strong influence on the degree of self-thinning. Mixed indigenous stand with initial density of 2.0 x 1.0 m had higher degree of self-thinning and at the age of 15 the survival rate was only 59 %. Average diameter was 10 cm and the largest one in the stand – 22 cm. Number of withered trees in the stand established by using vegetative saplings of selected clones planted at initial density of 4 x 4 m was insignificant. Average diameter of the stand was 21.6 cm and the largest one was 34 cm. The volume stock of the denser stand was smaller – 98 $m^3 \cdot ha^{-1}$, while the stock volume of the stand with a larger growth space was 165 m^3 per ha (Table 3). The logs produced by selected clones were larger. Stems were relatively well self-pruned, straight and provided a better assortment with a larger percentage of valuable wood. Under the same conditions Black pine stand had volume stock of 198 $m^3 \cdot ha^{-1}$.

At the same locations indigenous forest consisting mainly of Turkey oak (*Quercus cerris*) of coppice origin had volume stock 120 $m^3 \cdot ha^{-1}$ at the age 25 (Table 3). Both Turkey and Pubescent oak trees had small average diameters of 12 cm, while the one was in some cases more than 20 cm. Most stems were not straight and could only be used for firewood, chemical processing, and (a small amount) as construction material.

Table 3. Growth and yield of some tree species in the vicinity of the village of Paisiy.

Plot No	Tree species	Pattern, m	Density, ha^{-1}	Live trees, ha^{-1}	Survival, %	Age, years	Diameter, cm			Height, m		Stock, $m^3 \cdot ha^{-1}$	
							average	min	max	average	max	debarked	with bark
1	*Quercus rubra*	2.4 x 1.2	3472	1597	46,0	21	13	6	16	13.80	15.6	138.20	154.70
2	*Quercus rubra*	3.6 x 1.8	1543	1305	84,6	20	14	6	25	14.00	16.00	74.10	83.00
	Cedrus atlantica	3.6 x 1.8	1543	979	63,5	20	18	7	25	13.00	15.00	60.22	67.26
	Total											134.32	150.26
3	*Tilia tomentosa*	3.6 x 1.8	1543	1465	95,0	20	11.5	6	21	11.8	15.00	87.00	102.10
	Cedrus atlantica	3.6 x 1.8	1543	648	42,0	20	18.5	6	24	13.60	14.80	39.46	44.07
	Total											126.30	146.17
4	*R. pseudoacacia*	2.0 x 1.0	5000	2950	59,0	15	10	6	22	12.00	14.50	88.20	98.00
5	*R. pseudoacacia*	4.0 x 4.0	625	619	99,0	20	21.6	14	34	18.00	21.5	139.00	165.00
6	*Tilia tomentosa*	2.0 x 1.2	4167	2515	72,4	21	10.5	4	18	11.60	14.20	180.50	212.00
7	*Pinus nigra*	2.0 x 2.0	2500	2015	80,6	20	16	8	24	10.00	13.00	170.30	198.00
8	*Quercus cerris 80 %*	Natural	1371			25	12	6	20	13.00	15.40	82.60	96.00
	Quercus fraineto 20 %	Coppice forest	348			25	12	6	20	13.00	15.00	20.60	24.00
	Total											103.20	120.00

Comparing the stock and quality of timber from plantation with these of indigenous forest showed that cultivated plantations are far more productive.

Conclusions

The initial planting densities of 2.4 x 1.8 m and 3.6 x 1.8 m for plantations of Douglas fir and Atlantic cedar facilitate survival of larger numbers of trees and provide better growth conditions and therefore, higher growing stock during the first 15 to 20 years after planting. Regular thinning is necessary for production of more valuable stems.

Planting density schemes with greater spacing between the rows – 3.6 or 4.0 m – should be used in the establishment of intensive forest plantations. Both deciduous and coniferous species are suitable for intensive plantations in the lower forest belt (up to 600 m a. s. l.). Suitable coniferous species are Austrian Black pine and Douglas fir. Atlantic cedar could also be used but only under suitable environmental conditions. Of deciduous species Black locust, Red oak and Silver lime could be recommended.

Denser initial planting patterns do not cause sufficient self-pruning of coniferous species. In order to produce knot-free timber these stands should be additionally pruned.

Initial planting density affects the growth and the stock of Black locust. Increasing the growth space from 2 to 16 m^2 per sapling stimulates its diameter growth.

The intensive forest plantations at the age of 20 or 21 have two to three times higher growing stock than the indigenous forest stands.

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INVESTIGATION ON WORK TIME AND PRODUCTIVITY OF FOREST SKYLINE KOLLER K 300 IN OGRAZHDEN MOUNTAIN

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Abstract

The aim of the present investigation was to establish the duration of work time and productivity of a mobile forest skyline Koller K 300 in Ograzhden Mountain.The length of the studied road-track was 270 m and the transported wood was of Common beech (*Fagus sylvatica* L.). The terrain investigations were carried out with 107 work courses of loaded carriage for a period of four days. Each work course was divided into nine phases. It was established that most time was used for the work phase 'Motion of the loaded carriage to the landing site' similarly to other terrain investigations. The average productivity was 3.22 $m^3 \cdot h^{-1}$. The results indicate that with a proper organization the forest skyline Koller K 300 could yield very good productivity.

Key words: hauling distance, Koller K 300, load, productivity.

Introduction

After the structural changes in forest sector in Bulgaria that took place in 1998-1999 all activities concerning logging were transferred to private companies. This lead to total change of the work organization in the forest sector. Thirty forest skylines Koller K 300 imported in a course of 80 years, together with all available forest machinery went to private companies, too. Most companies do not fully utilize the capacity of the skylines they own because of requirements for the specific abilities for working, peculiarities of the exploitation and because of inadequately developed road infrastructure. The attempts for work with forest skyline Koller K 300 often did not provide satisfying results – frequent failure, low economic profitability, low productivity, as well as cases of staff injuries. Relatively good results were achieved only in regions with long-term traditions and trained workers. At the same time, some published results showed that the extraction of timber using sky-lines is more environmentally-friendly even than that using animal pulling power (Naghdi et al. 2009).

The investigations of sky-lines in Turkey showed that the productivity depends mainly on the length of hauling distance and the number of transported pieces in one stand (Senturk 2007, Çaliskan et al. 2005). It was pointed out that slope of the sky-line and weight of the carriages are also important factors affecting timber extraction process (Erdas and Eroglu 1999).

No such studies were carried out in Bulgaria during the last 20 years. German and Czech standards for planning of the cost of lumbering were used, after being adapted to Bulgarian conditions (Markoff and Glushkov 2008).

Therefore, the objective of the present study was to investigate the working processes and reliability of the sky-line used in the forests of Bulgaria.

Materials and Methods

The investigation was carried out during the summer of 2009 on the territory of Parvomay Forest Service, Ograzhden Mountains. The cutting area was situated on a steep slope, at altitude 930 m a.s.l. Beech wood was subjected to harvest. The silvicultural system applied was uniform graduate felling, lightenning phase, with 25 % intensity. The volume marked for cutting was 210 m^3. All logs were transported by yarding lifting the timbers suspension positions.

The instruments used were digital chronometer, inclinometer, compass, and meter stand maps at scale 1:10 000. Management plans, silviculture plan and data related to harvesting activities were obtained from the State Forest service in the study area.

The working time was studied using the IUFRO WT 3.04.02 classification. Time was divided into 10 working periods totally, or phases of one work cycle. The time needed for extraction of timber of a definied load from cutting area to the upper station was considered as one full work cycle. One minute (60 seconds) was assumed to be 100 and all other calculations were done accordingly. The working phases for one cycle were as follows:

Y1 – Hauling back of empty carriage;

Y2 – Descending of empty hook;

Y3 – Pulling of hook to log and attaching of loads;

Y4 – Pulling of loaded hook to carriage;

Y5 – Moving of loaded carriage to landing site;

Y6 – Descending of loaded hook to ground;

Y7 – Unhooking the loads;

Y8 – Pulling backwards of empty hook;

Y9 – Nonworking time (covering spare and delay time of workers);

Yst – Total working time for each shift;

X1 m – Distance, of logs at the layout of the line;

X2 m – Distance of dragging loaded carriage with carriage rope;

V m^3 – Transported timber volume.

The tractor used for Koller K300 was Universal-651, produced in Romania. Detailed description is given in Table 1.

Results and Discussion

It was establishes that fan-shaped method was used in the cutting area as only the rope at the lower pillar was removed. The skyline was displaced in a small area above forest lorry road since carriageway road was used as loading platform. The tractor was positioned in parallel to the forest lorry road and road layout was positioned perpendicular to the road. Two pillars were used of the main line, 50 m and 270 m from the upper station, respectively. Standing alive trees were used as pillars. Supporting spars were put on height of 14 m for the upper pillar and of 16 m for down pillar. The average slope of the layout was 37 °.

The installation of the supporting spar from live pillar tree was a typical peculiarity of this skyline. In the most cases this

Table 1. Yarder specifications for forest skyline Koller K 300.

Model	K 300
Height of tower	7 m
Model of tractor	Universal-651
Engine	50 kW
Skyline length	350 m
diameter	16 mm
Mainline length	350 m
diameter	10 mm
Pull	18 kN
Speed	3.2 $m \cdot s^{-1}$

operation was done by worker with the help of special cats put on the shoes allowing climbing to certain height of the tree. In this case a ladder was done from split branches with diameter 0.05–0.07 m hammered with 4–5 nails to the stem of the respective tree at distance 0.7 m from each other. The advantage of such pillars is that the workers have a quick and easy approach to the supporting spar and can easily remove eventual damages springing up in the process of work. The greater charge of the time for doing such ladder can be pointed as fault in comparison with the standard method of work.

The team working with forest skyline Koller K 300 consisted of 4 people: a yarder operator of the skyline and a worker cutting the stem at defined length at the upper station; a worker attaching the stems in the cutting area and a worker who cuts and log at the down station. The worker who cut trees at the down station worked independently and did not participate in extraction of timber, with the exception of loading the lorry with firewood. His main role was cutting, trimming and logging of the timber needed for extraction during the relevant work day. Typical peculiarity was that cutting of trees was carried out only trough work phase **Y5: Moving of loaded carriage to landing site**. Woody wedges were used for directing of trees during of the cutting. In this way the danger of trees falling above the main line was minimized.

Besides forming the load the worker who attached the stems in the cutting area, trimmed the thin branches remaining on the stem, which was the reason for frequent stops during work phase **Y4: Pulling of loaded hook to carriage**. It increased the time of relevant working course and decreased the total productivity.

The worker who cut the stems at defined length at the upper station, unhooked loads from the carriage and logged stems for firewood and construction timber, which. These two timber types were stacked on different loading platforms. The construction timber was moved with forest skyline Koller K 300. Including these additional operations in working phase **Y7: Unhooking the loads** caused frequent stops for drawing out the extracted timber, because the small area of the used loading platforms contained only up to 50 m^3. In this case the lack of extra winch for arranging of the loading platform leads to decreasing of the total productivity of the skyline.

The yarder operator of the forest skyline Koller K 300 was the team leader. He drove the jeep and was responsible for the supply with fuel and lubricating oil. During the work he was dealing only with the skyline operation.

It should be pointed that the cutting area was situated 30 km from the village where the working team was living. In this way the travelling to the work place was taking up to 3 h and 45 min on average every day.

A total of 107 work cycles were measured during the investigation of the skyline work time. The results are given in Table 2.

Distribution of the work phases in the average work time was determined as Y3 > Y5> Y9 > Y7 > Y1 > Y4 > Y2 > Y6> Y8.

The work phase **Y3: Pulling of hook to log and attaching of loads** was the most time consuming. It was due to many factors but mainly to significant hauling distance, which was 33 m in average. Furthermore, the worker forming the load at the down station trimmed with axe the stems of already hooked stem sections. The steep terrain as well as the messy brushwood caused additional difficulties to the work of load formation. The operation **Y5: Moving of loaded carriage to landing sit** was taking significant amount of time, too. This phase depend mostly on the drawing out distance, in this case being between 150 m and 265 m. Different kinds of stops were included in the skyline in work phase **Y9: Nonworking time** (covering spare and delay time of workers) and they cannot be classified separately. The most frequent reason for this was catching of extracted loads to trunks and staying trees. The data about the productivity of the Koller K 300 Mobile Skyline are as follow: 0.60 $m^3 \cdot shift^{-1}$, 3.22 $m^3 \cdot shift^{-1}$ and 25.76 $m^3 \cdot shift^{-1}$.

The productivity of Koller K 300 Mobile Skyline can be defined as moderate. Our results are comparable with those published in Turkey – 4.9 $m^3 \cdot h^{-1}$ with 250 m drawing out distance (Senturk 2007).

Table 2. Work phases and their percentages in average shift time consumption.

Sledge Winch Skyline		Work Phases									
		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Yst
Time consumption	s	64	14	187	54	138	5	84	5	107	659
	%	9.7	2.1	28.3	8.3	21.0	0.8	12.7	0.7	16.3	100

The correlation analysis aiming at determining the degree of relationships between different work phases, drawing out and hauling distance, and timber volume extracted through each course. The results are presented in Table 3.

Statistically significant correlation coefficients were established during the working phases: **Y1** correlated with **X2** (0.543)**, Y3** – with **X1** (0.461)**, Y4** – with **X1** (0.804) **and Y5** correlated with **X2** (0.473).

There were few significant correlations:

1. **Y1: Hauling back of empty carriage** moderately (0.543) correlated with **X2: Dragging distance** (expected value was close to 1). This result shows that the

Table 3. Correlation coefficients.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
X1	0.485	0.076	0.461	0.804	0.665	-0.133	0.158	-0.005	0.030
X2	0.543	0.181	0.405	0.428	0.473	-0.077	0.146	-0.145	0.053
V, m^3	0.104	0.129	-0.030	0.122	0.051	-0.094	-0.091	-0.050	0.020

operator could not control a carriage precisely all the time.

2. **Y3: Pulling of hook to log and attaching of loads** moderately (0.461) correlated with **X1: Load distance** (expected value was close to 1). This could happen because the load was not standardized, but there are a lot of other factors, so hypothesis should be defined more accurately. In order to minimize time period it is necessary to standardize timber heap. That includes: allocated worker(s) only for load preparation, cutting of boughs from logs, optimizing of log structures.

3. **Y4: Pulling of loaded hook to carriage** significantly (0.804) correlated with **X1: Load distance**. This result was expected and the practical aspect is establishment of timber heap near the skyline-bed. Using of special motor saw for trimming could be recommended for avoiding the periods of stay during the work phase, since a lot of time is lost for trimming. The worker forming the load should not deal with other kind of activity.

4. **Y5: Moving of loaded carriage to landing site** is average (0.473) correlated with **X2: Dragging distance** (expected was nearby 1). That shows that the operator could not control a carriage precisely all the time (same as point 1). In order to minimize time period **Y5** it is necessary to ensure fast and effective feedback information for skyline operator, which will provide him with opportunity for more precise carriage manipulation. That could be done with camera on the carriage and monitor on operator station.

5. Weak correlations between period times and timber capacity show their independence of current timber load. These results indicate that the time of one full work cycle was not influenced by the load volume.

6. In order to minimize time period **Y9: Nonworking time** (covering spare and delay time of workers) it is necessary to improve planning of activities and internal organization of people. That will increase the effective working time with the skyline.

Conclusions

1. Average productivity of skyline Koller K 300 in Ograzhden Mountain was 3.22 $m^3 \cdot h^{-1}$ for 33 m load distance and 230 m transportation distance.

2. To increase the productivity, time periods Y3 (28 %), Y5 (21 %), Y9 (16 %) and Y7 (13 %) should be minimized.

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THE MOST IMPORTANT FUNGAL DISEASES OF TREES AND SHRUBS IN GREEN PLANTINGS OF MOSCOW AND MOSCOW SUBURBS

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Abstract

The present paper presents information on the species composition, features of distribution and harmfulness of dendrotrophic pathogenic fungi, based on long-term observations on the health status and diseases in different types of urban plantings in Moscow and some towns of Moscow suburbs. The survey revealed more than 300 species of pathogenic fungi causing various diseases on roots, trunks, branches, leaves and needles in more than 70 species of coniferous and deciduous trees and shrubs, including a lot of introduced woody plants. Special attention is given to the diseases decreasing durability, protective and aesthetic functions of urban plantings.

Key words: fungi, diseases, woody plants, urban plantings, Moscow, Moscow suburbs, Russia.

Introduction

Green plantings are an integral part of urban planning structure and play an important role in improvement of the urban environment. The green fund of Moscow represents a set of green areas of different type and purpose, including plantings along streets and highways, plantings in yards, squares, parkways, parks, gardens, and territories of 39 amenity forests within the city boundaries.

Development of green plantings of Moscow and its suburbs proceeds under intensive influence of adverse anthropogenic and natural factors. By the end of the last decade in connection with growing anthropogenic influence on the status of city environment and deterioration of the ecological situation in Moscow, an imminent need arose for reestablishment and increase of resistance, ornamental, sanitary-and-hygienic and other diverse properties of green areas of the city. Following an order of the Moscow Government, a large-scale work began in 1997 within the framework of the general city program of monitoring of the condition of green plantings in Moscow (Mozolevskaya 1998, Yakubov 2001, 2005). Problems which were stated before forest pathologists first of all, consisted in estimation of the sanitary condition of urban plantings and the level of diseases and pests. Forest and ornamental nurseries were also surveyed, from which the planting material was delivered to Moscow and Moscow suburbs. The study period covered 10 years.

The paper presents basic results of studying species composition of phytopathogenic fungi and their role in worsening the urban plantings condition and decrease of their ornamental properties.

Material and Methods

Field studies were carried out with the use of methods of forest pathological inspections developed by the Department of ecology and protection of forest of the Moscow State Forest University (Mozolevskaya et al. 1984, Vorontsov et al. 1991). The sanitary condition of plantings and the level of diseases were estimated in the sample areas established in different types of urban plantings in Moscow and some towns of Moscow suburbs, including Mytischy and Korolev. At the same time samples of affected parts of plants were selected for investigation in laboratory conditions. Studying of species composition of fungi was carried out also on routes. The Russian and foreign literature was used for identification of species of fungi.

Results and Discussion

As a result of long-term observation of different urban plantings types in Moscow and some towns of Moscow suburbs more than 500 species of dendrotrophic fungi were identified, from which 327 species were pathogenic fungi causing various diseases of roots, trunks, branches, leaves and needles in more than 70 species of coniferous and broad-leaved trees and shrubs (Sokolova et al. 2006, Kolganikhina and Sokolova 2009, Sokolova and Kolganikhina 2009). Among them there was a group of the most active pathogens, causing essential harm to woody plants, which deserved special attention.

The most widespread diseases of leaves in urban plantings were powdery mildews, leaf spots and leaf rusts. Oak (*Quercus robur* L., pathogen *Microsphaera alphitoides* Griffon et Maubl.), maple (*Acer platanoides* L. and *A. ginnala* Maxim., affected mainly by *Sawadaea tulasnei* (Fuck.) Homma; *A. negundo* L. and *A. tataricum* L., affected mainly by *Sawadaea bicornis* (Wallr.:Fr.) Miyabe), and birch (*Betula pendula* Roth., pathogen *Phyllactinia guttata* (Wallr.:Fr.) Lév.) were the species most strongly affected by powdery mildews. The powdery mildew of horse-chestnut (*Aesculus hippocastanum* L.) caused by *Uncinuella flexuosa* (Peck.) U. Braun was found to a great extent in some plantings. Some shrub species were also strongly affected by powdery mildew: *Caragana arborescens* Lam. – by *Microsphaera palczewskii* Jacz., *Berberis vulgaris* L. – by *Microsphaera berberidis* (DC) Lév., *Lonicera tatarica* L. – by *Microsphaera lonicerae* (DC) Wint. and also species of rose (*Rosa* L.) – by *Sphaerotheca pannosa* (Wallr. ex Fr.) Lév. var. *rosae* Woronich. The listed species of woody plants were affected by powdery mildews each year.. Foliage diseases resulted to a great extent in almost full or sometimes full loss of ornamental properties of trees and shrubs and decrease of their protective functions.

Leaf spot agents as *Discula umbrinella* (Berk. ex Broome) Sutton affecting Lime and Oak, *Discula betulina* (Westend.) Arx affecting Birch, *Phyllosticta sphaeropsoidea* Ellis et Evern. affecting Horse-chestnut are widespread in plantings in Moscow and Moscow suburbs. In some years *Marssonina populi* Sacc. and *Septoria populi* Desm. developed massively on the leaves of poplars. *Dothidella ulmi* (Duv.) Wint. was also found to a great extent on the leaves of elms (mainly *Ulmus laevis* Pall. and *U. pumila* L.) in certain years. The leaf spot of maple (mainly *A. platanoides*) caused by *Rhytisma acerinum* Fr. was often observed on young plants in amenity forests and plantings in yards. The following leaf spot agents were widely spread on shrub species: *Sphaceloma symphoricarpi* Barrus. ex Horsfall. affecting *Symphoricarpos albus* (L.) Blake, *Marssonina rosae* (Lib.) Died. affecting roses, *Phyllosticta michailowskoensis* Elenk. affecting species of hawthorn (*Crataegus* L.). Some diseases of this category resulted in premature defoliation which entailed partial or full loss of ornamental properties and resulted in weakening of plants. So, for example, during mass development of leaf spots on Poplar, Oak and Birch the trees lost up to 50% of foliage already in the middle of the summer and that resulted not only in full loss of their ornamental properties, but also in decrease of their protective functions.

The leaf rust on Poplar (mainly *Populus nigra* L. and *P. balsamifera* L.) caused by *Melampsora larici-populina* Kleb. and *M. allii-populina* Kleb. was recorded yeach year in the plantings in Moscow and its suburbs. Sometimes the leaf rust on Birch caused by *Melampsoridium betulinum* Kleb. was observed to a great extent. The leaf rust of *Caragana arborescens* caused by *Uromyces laburni* (DC) Otth. and on the Rose species (especially on *R. canina* L.) caused by *Phragmidium mucronatum* (Pers.:Pers.) Schlech. periodically developed quite strongly in some plantings. In the years of mass development these diseases resulted in premature defoliation, decrease of ornamental properties and weakening of plants.

Diseases of needles were mostly spread and had the greatest importance for young plants in various categories of urban plantings. *Lophodermium* needle cast caused by *Lophodermium pinastri* Chev., which frequently serves as the indicator of weakening of plants, is the most widespread disease on needles of different pine species.

For the last 20 years agents of dangerous diseases in needles not found before have been registered in the Moscow region: *Cyclaneusma minus* (Butin) Di Cosmo, Peredo & Minter, *Dothistroma septospora* (Dorog.) Morelet and *Brunchorstia pinea* (Karst.) Höhn. Currently these pathogenic species do not have wide distribution in the Moscow region. They were recorded, basically, in some private possession, while the level of their development is low. However, all they possess potential danger to plantings of Moscow.

In urban plantings and in private possession *C. minus*, causing needle yellowing of pine (Cyclaneusma needle cast of pine) has been found quite often on a few species of pine, including *Pinus mugo* Turra, *P. sibirica* Du Tour and *P. nigra* Arn. It is known that it occurs worldwide and affects more than 10 pine species. *C. minus* is characterized by high parasitic activity and affects needles of the trees, which do not have signs of weakening. The disease development results to a great extent in thinning the crowns, weakening of trees and decreasing their ornamental properties.

Now *Dothistroma septospora*, causing needle red spot of pine (*Dothistroma* pine needle blight or red band needle blight), is registered in many countries of Europe and America, in some countries of Southeast Asia and Africa, and in Australia. On the territory of the former USSR this disease was reported from Georgia and Kazakhstan. This fungus affects many pine species, including *P. sylvestris* L., *P. pallasiana* D. Don and others. In the Moscow region it was found on needles of *P. nigra*. *D. septospora* is characterized by high parasitic activity and it is the reason of premature needle dieback and defoliation. The disease results in mass weakening of young plants and decrease of their ornamental properties, and less often destroys them.

Gremmeniella shoot canker caused by *Gremmeniella abietina* (Lagerb.) M. Morelet (anamorph: *Brunchorstia pinea* (Karst.) Höhn.) can affect species of pine, spruce (*Picea* A. Dietr.), fir (*Abies* Mill.) and larch (*Larix* Mill.). It is known from the Scandinavian countries and Baltic States. On the territory of Russia it was registered on Kola Peninsula and in the Volga region. Once this fungus was mass recorded on *Pinus sibirica* in one of nurseries in the Moscow region. The anamorph stage (*Brunchorstia pinea*) was recorded only on needles (not on shoots) of *Pinus sylvestris* in Moscow and Moscow suburbs.

Needles of different spruce species are frequently affected by *Lophodermium* needle cast caused by *Lirula macrosporum* (R. Hartig) Darker. Recently the Rhisosphaera needle cast caused by *Rhisosphaera kalkhofii* Bubak. developed quite strongly on *Picea pungens* Engelm. and *Pseudotsuga menziesii* (Mirb.) Franco in some places in Moscow and Moscow suburbs.

Lophodermium needle cast of junipers (*Juniperus* L.) caused by *Lophodermium juniperinum* (Fr.) de Not occurs very frequently on different juniper species. *Pestalotiopsis funerea* (Desm.) Steyaert often develops on needles and branches of the species (including *J. sabina* L., *J. virginiana* L.) and thuja (*Thuja occidentalis* L.). More often this fungus affects the plants injured by frosts or predisposed to disease due to growing in adverse conditions.

Diseases of branches, trunks and roots are the most important group of diseases of woody plants in the city plantings. The Dutch elm disease caused by *Ophiostoma ulmi* (Buissm.) Nannf. occurs in all areas of Moscow and towns of Moscow suburbs. It affects different species of elm, including *Ulmus laevis*, *U. glabra* Huds., *U. pumila*. For the last 20 years this disease has resulted in disappearance of the whole plantations of this tree species. The increase of hotbeds of the Dutch elm disease in the sharp form has recently been observed.

Among dieback diseases, many of which are dieback and canker, *Cytospora* diebacks are widespread on different deciduous tree species, especially on Poplar, caused by *Cytospora chrysosperma* (Pers.) Fr. and *C. leucostoma* (Pers.) Sacc. and also on Lime, Mountain ash (*Sorbus* L.) and Hawthorn, caused by *C. leucosperma* (Pers.) Fr. The disease was frequently recorded on linden and poplar growing in adverse conditions.

Nectria (*Tubercularia*) canker and dieback caused by *Nectria cinnabarina* (Tode: Fr.) Fr. (anamorph: *Tubercularia vulgaris* Tode) occured in many deciduous tree species. In Moscow it represents the greatest danger for young plantings, especially horse-chestnut, mountain ash and linden. *Colpoma* dieback caused by *Colpoma quercina* (Pers.) Wallr. and *Vuilleminia* decay caused by *Vuilleminia commedens* Maire resulted in weakening of plants in young plantings of oak in some places of Moscow.

Among dieback diseases of coniferous tree species it is necessary to mention *Sphaeropsis sapinea* (Fr.) Dyko & B. Sutton. This pathogen develops not only on branches but also on needles of pine.

Thyrostroma canker and dieback caused by *Thyrostroma compactum* (Sacc.) Höhn. affected different species of Lime and Elm (especially strongly *Tilia cordata* Mill. and *Ulmus pumila*) in Moscow. The fungus was registered for the first time in 1976 in the Moscow Region on the branches of a Lime tree. For the next 10 years it was found in different regions of the country in natural and urban plantings.

In plantings of Moscow and Moscow suburbs the disease was registered at the beginning of 1980s. From the middle of 1980s till now it has been spread in all categories of plantings of Moscow and has caused mass weakening, decrease of ornamental properties and dieback of Lime trees. Therefore, mass cuttings of Lime were carried out, especially along highways, and also in the street and yard plantings. All this resulted in reconstruction of some part of plantings in Moscow. Though the disease was registered in different types of urban plantings, in the most polluted environmental conditions (along large highways) the fungal stroma did not develop, but under favorable conditions the signs of the disease were revealed more precisely. This was probably due to the fungicide action of environmental pollutants. The disease affects different age trees of Lime, including nurseries. In the stands of amenity forests the disease affected both adult trees and understory.

Perennial *Neonectria* canker of deciduous tree species caused by *Neonectria galligena* (Bres.) Rossman & Samuels frequently occured in different categories of urban plantations. Most frequently it affects Lime, Maple and Ash. Black *Hypoxylon* canker of Aspen and Poplar caused by *Hypoxylon mammatum* (Wahl.) J.H. Miller occurred seldom; more frequently it developed on *Populus alba* L. and *P. tremula* L. Black *Botryosphaeria* canker of apple-tree (*Malus domestica* Borkh.) caused by *Botryosphaeria obtusa* (Schwein.) Shoemaker (anamorph: *Sphaeropsis malorum* Berk.) represents danger to old apple-tree plantings. Quite often the agent causing this disease and that of *Cytospora* dieback, caused by *Cytospora schulzeri* Sacc. & P. Syd. developed simultaneously on the large skeletal branches and trunks of apple-trees.

The pitch blister rust canker affecting trunks of *Pinus sylvestris* caused by *Cronartium flaccidum* (Alb. et Schwein.) Wint. was widely spread. It occurred both in amenity forest, and on planted trees and shrubs territories of the city, with some remnants of old trees from previous plantings. Stem rust of pine caused by *Cronartium ribicola* Dietr. affected trunks and branches of *P. sibirica* and *P. strobus* L., which are sometimes used in plantations near offices.

Among the agents of root rots *Heterobasidion annosum* (Fr.: Fr.) Bref., *Armillaria* species complex (*A. mellea* (Vahl.: Fr.) Kummer is the type species), were particularly frequently recorded in the coniferous plantations, and *Phaeolus schweinitzii* (Fr.: Fr.) Pat. occurred in the stands of amenity forests. The *Armillaria* species complex, *Phaeolus schweinitzii* and *Ganoderma applanatum* (Pers.) Pat. were most frequently recorded in the street plantings and in other parts of the city. In different categories of plantings *Armillaria* species complex affected trees preliminary weakened by various factors of technogenic nature.

Of the agents of trunk rots in coniferous tree species the fungi *Phellinus pini* (Thore ex Fr.) Pil., *Ph. chrysoloma* (Fr.) Donk, *Onnia triqueter* (Lentz.: Fr.) Imaz. Per S. Ito were widely spread in the stands of amenity forests. The most frequent there were *Phellinus igniarius* (L. et Fr.) Quel., *Fomes fomentarius* (L.) Will., *Polyporus squamosus* (Huds.ex F.) Fr., *Laetiporus sulphureus* (Bull.: Fr.) Murrill, *Pholiota adipose* Fr., *Bjerkandera adusta* (Willd.: Fr.) P. Karst., *Chondrostereum purpureum* (Fr.) Pouz. and others, attacking deciduous tree species in all types of green plantings.

Root and trunk decays represent the greatest danger for street and yard plantings, squares, parkways and other planted trees and shrubs territories of city. These diseases cause windfall and windbreak with squally and gale-force winds and therefore represent danger to people, buildings and constructions.

Conclusions

The study demonstrated that fungal diseases are one of the most important factors lowering durability, protective and aesthetic functions of urban plantings.

Infectious diseases penetrate into plantings in Moscow and Moscow suburbs with the planting material from the Russian and foreign forest and ornamental nurseries. First of all, the following factors contribute to the wide circulation of infectious diseases agents in urban plantings: the insufficient control over the planting material imported from other regions of Russia, local nurseries and from abroad; absence of appropriate conditions of keeping of the planting material in nurseries, violation of the regulations while transporting and planting, which results in worsening of plant conditions and decreasing of their disease resistance; discrepancy in climate types to growing conditions; delayed destruction of sources of infection; influence of the urban environment.

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CRITICAL CONTROL POINTS /CCP/ OF RISK DETERMINATION AND CONTROL SYSTEM OF HACCP IMPLEMENTATION IN THE PRIVATE FORESTRY

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Abstract

Forest quality and growth sustainability can be influenced by many risk factors throughout the development process: human activity, environmental conditions change, the effects of global warming, water and soil pollution, forest pests and diseases, proliferation, wild animal damage. Ensuring the safety and quality of forest stands of timber approach to consumers needs methods to predict and identify potential risks and determine their potential impact. Real situation calls for new studies in detecting weaknesses and errors in the control and management system for all forest development stages of the technological process. His main objective to explore the food industry HACCP systems proved their worth of applications in the private forestry with the aim to provide customers with stable and high-quality timber resources.

Key words: private forestry, risk analysis, state forestry services.

Introduction

Forests and forest management in general is not only organic, but also environmental, economic and social system. Therefore, to make this complex system work appropriately, the work of one or more sub-satisfactory systems is insufficient.

Good illustration will serve a freshly cut tree. Tree skidders can start right away, but it will be difficult. The problems in the skidding are the great branches that had not been cut. Sometimes in this point the skidding process could be stopped. This is the critical point.

In this point we should look at these branches that could also be called critical control points, otherwise they will disturb the manufacturing process.

Forest growth, development and sustainability are influenced by many risk factors throughout the development process. The main among them might be:

– Political situation in the country.
– Economic situation in the country.
– Environmental situation in the country.
– Population intellectual level.
– Environmental conditions change.
– Global warming or cooling.
– Water and soil pollution.
– Forest pests and diseases, proliferation.
– Wildlife damage.

To guarantee the safety of forest growth and wood quality approach to customers, methods to predict and identify potential risks and determine their potential impact are necessary.

The real situation requires filling in the new research gaps and improving the unused opening moments existing concerning control and management system for all forest development process stages. The main tasks put forward are to explore the possible use of HACCP systems in the private forestry with the aim to provide consumers with stable and high-quality timber resources.

Materials and Methods

At the beginning of the study, first, it was necessary to survey more literature on risk control and management system (HACCP) techniques in the food industry (Avsjukovs et al. 2004, Blija 2005, Flynn 2000, Food …1998); second, the following issues can be considered in outlining the HACCP system, as forest biological diversity, stability and quality; third, developed by CP (critical point) structure identification of options, with further clarification, substantiation and implementation of forest sustainability in all aspects account for the further study of key content.

HACCP stands for Hazard Analysis Critical Control Point, the critical point (phase) identification and management of the whole process (Blija 2005).

HACCP is a tool that allows the company, institution or process management to apply more structural approach to risk causes and better control than is possible with traditional inspection and quality control procedures (Kaktiņš and Arhipova 2002, 2003, 2005a, 2005b). It is potentially able to identify the product, process or system process during which so far no failure was experienced and is, therefore, especially useful for emerging technologies.

To start using the HACCP based systems it is necessary first to carry out risk assessment of forest management and monitoring process.

Risk assessment (Food … 1998) is a process in which the risk of probable causes and their possible effects on the forest management process is evaluated (Kaktiņš et al. 2007) in general. It is necessary to eliminate the two important factors related to risk assessment:

– Risk likelihood or probability of causation.

– The consequences if it is realized.

Risk assessment is carried out by analytical work. It includes both quantitative and qualitative risk assessment. Risk assessment can be described in legislation (Meža politika 1998, LR Meža likums 2000), administrative system, education of forest owners, property size, economic opportunities for forest management, forest access, technology used, etc., and to include information available and literature research, and consultations with experts in the field (Meža enciklopēdija 2003).

The traditional evaluation model consists of the cause of risk identification, characterization, practical expressions of evaluation and characterization (Food … 1998).

There is a very sophisticated risk assessment scale. Of these appearing in the literature, the simplest is one that described the risk assessment scale and quantified risk assessment for each considered point.

Using Risk Analysis

The identification of critical control points (CCP`s) can also be done by using the risk analysis and the obtained risk categories (Table 1). For example:

Table 1. The scale of risk assessment.

Probability	high	4	5	6	7
	real	3	4	5	6
	small	2	3	4	5
	very small	1	2	3	4
		very limited	moderate	serious	very serious
	Effect				

Source: Neyts et al. 2000.

Risk category 1 – no additional measures or controls required;

Risk category 2 and 3 – control points;

Risk category 4 and more – CCP.

Results and Discussion

Study was designed to assess the existing private forestry management system analysis and critical control point detection capabilities.

Forest Policy

Forest sector development affects the last 15 years, due to the international forest management concepts change. The concepts were reviewed in the light of existing forest policy aimed to ensure sustainable forest management and balance of the forest ecological, economic, and social functions (Kaktiņš and Arhipova 2005a).

To ensure sustainable forest management in line with international commitments, a new forest policy was developed (Saliņš 2003, Kaktiņš and Arhipova 2005b).

Potential risk management system for forest policy specifies four basic functions:

– Legislative – forest policy formulation and realization of the legal drafting.

– Monitoring – Law and legislation underlying law enforcement and compliance monitoring of all the forest owners.

– Owner – public and private forest property management, ensuring the values of conservation, enhancement and income state, and both private and public forest owners accepted the ecological and social functions.

– Support activities – activities carried out by the country with their own bodies and (or) funding to ensure sustainable forest functions in the stabilization and private sector development.

Implementing Forest Policy

Assessing forest policy, we can mark the strengths and weaknesses.

The strengths of:

– using climatically, geographically and traditionally long period of accumulated knowledge and skills in the country to built up favorable conditions for forestry;

– high quality, diversified and renewable forest resources can provide the processing plant operations, thus giving a major contribution to the employment problems of the countryside;

– forest sector established that is able to maintain stability of its products in international markets;

– characterized by certain functions between the industry's leading institutions, nongovernmental organizations and stakeholders;

– operators of private forest owner conscious of accumulated great knowledge of forest cultivation, restoration and use of a deep understanding of forest ecological, social and economic importance;

– industry bodies, leading companies and forest managers conscious part have mastered a foreign frontier forest restoration, forest production, processing and distribution technologies.

The implementation could face some weaknesses, which increases the potential risk of triggering the forest sector:

– lack of long-term development strategy objectives;

– forest sector imbalances – insufficient industrial capacity of low-quality wood and wood residues for recycling;

– small- and medium-sized enterprises and low competitiveness of the large ones;

– a large number of owners who operate small forest property (land);

– insufficient level of public awareness about the forest sector and its processes;

– insufficient funding and support for education and research, ensuring the competitiveness of the forest sector;

– ineffectively addressed issues concerning the use of wood waste in the economy, ensuring national energy independence and saving energy from other sources.

The Legal Basis Regulating Forest Management

Since independence the Latvian legislation system changed three times, which is reflected in the existing laws and their underlying laws and regulations established pursuant to 1998. Cabinet accepted regulations on forest policy.

Forest laws postulate what could be done in the forest, and determine what could be the human activity there.

Implementing Legal Acts Regulating Forest Management in Practice

The strengths of:

1st Creating of modern nurseries producing container plants not only in the Baltic countries, but throughout Eastern Europe.

2nd Step consists of restoring private forest property.

3rd Reduction of illegal forest cutting and theft.

Weaknesses, which increases the potential risk of triggering options in the forest sector:

1st A number of private forest owners are not interested.

2nd State forest Service, authorized by the state to monitor the private forest functions, did not allocate sufficient funds for this purpose.

3rd The issue of compensation to the forest and forest land owners whose land is located in protected natural areas, in which the force is operating ban, was not resolved.

4th there is a compromise between private forest owners economic objectives on the one hand and conservation objectives on the other.

5th There are several over-protected natural objects.

6th The issue of protection of private forest from wildlife damages is not completely solved.

7th Absence of a forest owner or manager of a single logistics system.

8th No measures were developed for fire regulations to prevent abuses of private woods and forests in the vicinity.

Institutions of the Forest Industry

One of the fundamental principles of the economic sector is the institutional structure of the selective stability of the sector confidence in the future. One of still remaining problems is the fragile state of Latvian products. Instability, which hampers the forest sector growth, strengthens the National Forest Service reforms.

Establishment shortening in terms of forest workers indicates:

1st Now the area under each forester or forestry is the care for, is so hugely popular that the lack of transport it is impossible to manage and control.

2nd Still not thoughtfully organized legislative action. Sticking to the roll arrangements are needed, but also provided within the framework of this policy is probably better to arrange the adoption of laws or amendments to laws. If the reforms would be deliberative, it would mean that they withstand the test of time. However, they followed after one another, but no improvement was achieved.

3rd Uncertainty about the sector also relies on industry specialists, so competition in the sector declined.

All these facts convincingly prove that the reform of National Forest Service that induced rearrangement of instrumentation could be a very serious CP.

Planning Forest Management

National Forest Service requests made of forest management – Inventory plans. They provide control capabilities for rational management of forests, environmental protection and sustainable use. This is not satisfied concerning much of the forest owners.

From all the above-analyzed set up a risk assessment table.

Table 2. Exposure assessment of risk in values.

No	Hazard identification	Risk assessment	CCP
1	Forest policy	6	CCP
2	Implementing forest policy	3...6	CCP
3	The legal basis regulating forest management	6	CCP
4	Implementing legal acts regulating forest management in practice	4...6	CCP
5	Institutions of the forest industry	3...7	CCP
6	Planning forest management	3...4	CCP

From the Table 2 we see that it is possible to impartially determine the analysis process the critical control points. Consequently, an opportunity and a real need at critical control points to take corrective action, process or system performance drastically improve.

Consequently, it has proved a critical control point of the method being applied. This opens up great opportunities for further research.

Conclusions

HACCP forest owners and managers, enabling more educated, more detailed and perceived risk causes than is possible with traditional quality control inspection procedures.

Using the HACCP system, control is transferred from the sole control of the final product to the entire process as a whole.

HACCP helps to describe the systematic nature of data and methodology, which is guaranteed in the process of realizing security.

To successfully implementation of HACCP systems by the forest holdings requires mobilization of resources for specific tasks.

HACCP, analysis of data collected makes it possible for forest owners and lessees to take economically sound decisions and develop policies that ensure equity holders and other consumer security with high quality timber while maintaining forest sustainability.

HACCP implementation can be effective in the private forest owners' associations, because small forest owners to engage their unambiguous.

HACCP introduction of the National Forest sector could be effective and feasible.

Private forestry can use some of HACCP principles, and not the entire system as a whole.

Real situation calls for new studies in detecting weaknesses and errors in the control and management system for all forest development stages of the technological process.

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NEW RECORD OF NUTRIA (*MYOCASTOR COYPUS* (MOLINA, 1782)) DOWNSTREAM OF THE MARITSA RIVER IN BULGARIA

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Abstract

Fragments of a scull and lower jaws of Nutria were found near river Maritsa, close to Harmanli town. There are suitable habitats for this species in the area, overgrown with reed and rush near the bank and the islands in the river. The location lies at about 50 km on a straight line from the nearest one known on river Maritsa in Turkey, and at about 35 km from another one in Bulgaria and probably results from invasion of the Nutria along the river.

Key words: *Myocastor coypus,* Bulgaria.

Nutria is a South American species introduced in Bulgaria in lake Mandrensko and Arkutino Natural Reserve, at the Southern Black Sea Coast in 1953 (Peshev et al. 2004). Inland, it was reported only from river Maritsa, near the city of Plovdiv (Popov 2003), and from river Salzliyka, at the drainage basin of river Maritsa near Radnevo town (Myhajlov, Stoyanov 2001).

The fragments of a scull and lower jaws were found near the den of a Red Fox (*Vulpes vulpes* (Linnaeus, 1758)) N 41° 56`, E 25° 56` on 18.02.2012, of 350 m on a straight line from the bank of river Maritsa, near Harmanli town. They were discovered by a hound dog which followed the bloody trail of the fight between the animals. The material was determined and measured up according to the detailed reports by Peshev et al. (2004) (Table 1). The sample was registered under No RM-1040 at the National Natural Science Museum in Sofia. All distances are measured using the Garmin eTrex Legend Global Positioning System and the program MapSource, Version 6.11.6 (Garmin Ltd.).

In the area of study, there are stretches overgrown with reed and rush along the bank and in the islands in the river. The adjoining territories are mainly arable lands. These habitats correspond to those described as suitable for the species by Özkan (1999) and Peshev et al. (2004). That is why we assume that it is possible for Nutria to reproduce in this region. The species occurs along the rivers Tundzha, Arda and Maritsa in Northwest Turkey (Özkan, Kurtonur 1994, Özkan 1999) and in North Greece (Carter 2002). Also, there is this species in Aras river from Northeast Turkey (İliker et al. 2009). The new location lies at about 50 km on

Table 1. Skull and mandible measurements of Nutria *Myocastor coypus*, the Maritsa River, SE Bulgaria.

No	Skull measurement	Dimensions, mm
1	Length of upper diastema DL	30.08
2	Coronary length of $P^4 - M^3$ $LcP^4 - M^3$	30.4
3	Coronary length of $P_4 - M_3$ $LcP_4 - M_3$	32.96
4	Length of the lower diastema LDL	21.66
5	Length of the foramina incisivi IFL	13.43
6	Width of the foramina incisivi IFW	2.17
7	Coronary length of $I_1 - M_3$ $LcI_1 - M_3$	65.11
8	Coronary length of $I^1 - M^3$ $LcI^1 - M^3$	67.01
9	Length of lower first molar LM_1	6.55
10	Length of lower second molar LM_2	8.72
11	Length of lower third molar LM_3	11.6
12	Length of first upper molar LM^1	6.55
13	length of second upper molar LM^2	9.19
14	length of third upper molar LM^3	9.75
15	width of first upper molar WM^1	6.65
16	width of first lower molar WM_1	5.99
17	width of second upper molar WM^2	7.95
18	width of second lower molar WM_2	7.35
19	width of third upper molar WM^3	8.02
20	width of third lower molar WM_3	8.12

a straight line from the closest one known on river Maritsa in Turkey and at about 35 km from the one on river Salzliyka (Maritsa drainage basin) in Bulgaria. It probably results from invasion of the Nutria along river Maritsa.

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