REGENERATION POTENTIAL OF STANDS DOMINATED BY *QUERCUS ROBUR* L. IN VARDIM ISLANDS

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Abstract

Regeneration processes in riparian forests in islands Vardim and Malak Vardim were studied. Stands in natural oak forests in the investigated region are insignificantly impacted by anthropogenic activities in the last 40-50 years. They are dominated by *Quercus robur* L. Among the native tree species *Populus alba* L., *Ulmus laevis* Pall. and *Pyrus communis* L. are mostly spread. The introduced *Amorpha fruticosa* L. and *Fraxinus americana* L. spread in large scales. The regeneration potential of *U. laevis* is good and to less extent - of *Q. robur*. Main reason for the unsatisfactory regeneration of *Q. robur* is grazing of wild animals. Carrying out of regenerating cuttings in Vardim oak forests is difficult due to the introduced limiting status of protected area. For the successful natural regeneration of *Quercus robur*, it is recommended to make fences around solitaire and groups of fruiting trees, as well as strict protection and soil scarification. To stop the further invasion of introduced species and to increase the participation of other native tree species, it is recommended the following: (i) reafforestations with hybrid Euroamerican poplars and other exotic tree species are no longer performed; (ii) clear cuttings in forests composed by native tree and shrub species are stopped; (iii) regeneration groups of *Quercus robur*, *Ulmus laevis*, *Populus alba*, *Populus nigra* L. and *Salix alba* L. are established. This could be done through supporting the natural regeneration (soil scarification, cutting of the understorey and sowing of seeds) or through afforestation with Vardim reproductive materials.

Keywords:*Quercus robur* L., island forests, natural regeneration

Rezumat

POTENȚIALUL DE REGENERARE AL ARBORETELOR DE STAJAR DIN INSULELE VARDIM

Lucrarea prezintă rezultatele cercetărilor privind regenerarea arboretelor edificate de stejar din pădurile ripariene din insulele Vardim şi Malak Vardim. Arboretele naturale edificate de stejar din zona de studiu au fost afectate nesemnificativ de activități antropice în ultimii 40-50 ani. Pe lângă stejar (*Quercus robur* L.), care constituie specia dominantă, cele mai bine reprezentate sunt exemplarele de *Populus alba* L., *Ulmus laevis* Pall şi *Pyrus communis* L., dintre speciile indigene, şi de *Amphora fruticosa* L. şi *Fraxinus americana* L., dintre speciile alogene.

Potențialul de regenerare este bun la *U. laevis* şi satisfăcător la *Q. robur*. Păşunatul de către vânat constituie principalul factor care afectează regenerarea stejarului. De asemenea, din cauza statutului de arie protejată a acestor insule, există restricții în ceea ce priveşte aplicarea tăierilor de regenerare. Pentru asigurarea regenerării naturale a stejarului (*Q. robur* L.) se recomandă împrejmuirea arborilor şi a pâlcurilor de stejari maturi însoțită de lucrări de pregătire a solului. Pentru a stopa invazia speciilor alogene de arbori şi creşterea proporției de participare a speciilor native, se recomandă: i) stoparea plantării de plopi euramericani şi de specii alohtone; ii) stoparea tăierilor rase în arborete de tip natural-fundamental; iii) crearea unor nuclee de regenerare pentru speciile native (*Q. robur, U. laevis, P. alba, P. nigra, Salix alba*). În acest sens sunt necesare activități de ajutorare a regenerării naturale (scarificarea solului, înlăturarea subarboretului, semănături) sau de împădurire utilizându-se materiale de reproducere locale.

Cuvinte cheie: *Qurecus robur* L., păduri ripariene, regenerare naturală

1. INTRODUCTION

Typical floodplain forests are characterized by the presence of more than two tree-and-shrub storeys and vegetation between the storeys. According to many features they remind of tropical forests. Floodplain forests in Bulgaria are situated mainly along the mouths of the rivers Batova, Kamtchia, Ropotamo, Veleka, along the lower courses of Tundzha, Maritsa and rarely along the Danube tributaries and islands (Stefanov, 1943; Marinov and Kanev, 1981). Today floodplain forests in Bulgaria are strongly influenced by human activity.

From scientific and forestry point of view, floodplain oak forests from Vardim islands are interesting for their age, size and specific features (Denev, 1966). These forests are the only more compact oak dendrocoenosis in islands from the Bulgarian part of the Danube. At the beginning of the 20th century, there were natural forest, small in size, on Kovatchev island, near the town of Lom (Stoyanov, 1948). Solitaire oak trees have been recorded on a couple of another Bulgarian islands - Batin, Persin and Masata.

The protected area Stariyat dub (The Old Oak) has been differentiated for conservation of oak forests on Vardim island and for protection of one of the biggest egret and cormorant colonies. The protected area were announced with a decree No.RD 939/22.07.1988 of the Ministry of Environment of Bulgaria, IUCN category IV, with a total area 98,4 ha (Georgiev, 2004). Ornithologically important places are included here (Kotseva et al., 1997). More than 40 bird species have been recorded, 12 of them being included in the Red Book of Bulgaria. Due to the fact that Vardim islands have high conservation value, it is foreseen to join the European Ecological Network NATURA 2000. A couple of habitat types are with priority according to Directive 92/43/??? (Action plan, 2003).

There is no unanimous opinion in Bulgaria about the taxonomic reference of Vardim oak. According to some authors this is *Quercus robur* L. (Petkov, 1940; Kochev, 1996; Hinkov, 2004; Kavrakova et al., 2005). Stoyanov (1948) claims that

there are *Q. robur* L. and *Q. pedunculiflora* C. Koch. growing on the islands. Tchernyavski et al. (1959), Denev (1966) and Tsanov (1992) think that *Q. longipes* Stev. occurs on Vardim island. In some Romanian publications (Georgescu and Moraru, 1946; Enescu et al., 1988) it is pointed out that the oak, which occurs to the north of Vardim island along the Romanian tributaries of the Danube, is *Q. robur*.

The natural forest vegetation on Danube islands is scanty compared to the floodplain forests in the interior of the country (Petkov, 1940; Stoyanov, 1948). Forests on Vardim islands are composed by *Salix alba* L., *Q. robur* L., *Populus alba* L., *P. x canescens* (Ait.) Sm., *P. nigra* L., *Ulmus laevis* Pall., *U. minor* Mill., *Morus alba* L. and *Fraxinus oxycarpa* Willd. The floodplain character of these forests is exalted by the presence of lianas *Vitis vinifera* L. ssp. *sylvestris*, *Humulus lupulus* L., *Solanum dulcamara* L., *Clematis vitalba* L., *Calystegia sepium* (L.) R.. Br. The introduced species *Fraxinus americana* L., *Acer negundo* L., *Gleditsia triacanthos* L. and *Ailanthus altissima* (Mill.) Swingle have been spread during the last decades. About 60% of the areas of the two islands are covered by plantations or coppice-regenerated after clear cuttings Euroamerican poplar hybrids. Among the shrub species, the following occur: *Rubus idaeus* L., *Crataegus monogyna* Jacq., *Cornus sanguinea* L., *Sambucus nigra* L., *Viburnum opulus* L., *Euonymus europaeus* L., as well as the widely spread exotic shrub species *Amorpha fruticosa* L. (Stoyanov, 1948; Penev et al., 1969; Strategy, 2001; Tsanov, 1992). Grass species *Euphorbia lucida* L., *Glycyrrhiza echinata* L. and *Leucojum aestivum* L. which are included in the Red Book of Bulgaria, could also be seen on the islands.

First phytocoenological investigations on Vardim islands have been carried out by Stoyanov (1948), who mentions the following forest associations, in which Vardim oak takes place: *Quercetum, Querceto-Ulmetum* and *Saliceto-Quercetum.* Tsanov (1992) represents community of *Inundo-querceto-longipes*, and later on Kochev (1996) shows five associations, which include *Quercus robur*.

Zahariev (1913) for the first time, ask the question of the proper oak forests management in Bulgaria, using the Russian experience from Shipov les and Tulski zaseki. Ruskov (1928), Radkov and Minkov (1963) recommended group selection and group-shelterwood reproduction methods for the successful regeneration of the high-stem oak forests in Bulgaria. Marinov (1956 a) claims that shelter wood regeneration method has been used until 1920 for the Romanian *Q. robur* forests at the north of and close to Vardim island. After that, group selection method has been practiced predominantly. The priority of this method is concerning the group regene-ration of the oak and the opportunities for its support and growing. Penev et al. (1969) characterize as difficult the natural regeneration of local tree species (with the exception of *Salix alba*) in the riparian Danube forests. Having in mind especially Vardim islands, Denev (1966, 1967) makes scientifically well-founded suggestions for the preservation of oak forests there. The same author (Denev, 1968) established that there are good opportunities for natural regeneration of Vardim oak. Numerous authors mention the fast growth of Vardim oak and its valuable wood, compared to the rest island tree species (Petkov, 1940; Tchernyavski and Pavlov, 1955; Denev, 1966). Having in mind the

Longoza forest (river Kamtchia), Kostov (2000) also has the opinion that it is possible to occur the natural regeneration of local species combined with intensive support. The author suggests eth entire change of the applied silvicultural systems and to introduce close-to-nature and sustainable management of these forests, giving also priority to main cuttings with longer regeneration period.

Concerning the regeneration processes in Vardim oak forests, no research investigations have been carried out during the last 40 years. The successional processes from these dendrocoenoses and the necessity of precise prognoses and recommendations for their development are the reasons for carrying out the present investigations.

Aim of the present work is to determine the character of regeneration processes in oak forests on Vardim islands.

2. OBJECTS AND METHODS OF INVESTIGATION

Object of investigation are the islands Varim and Malak Vardim (from $43^0$37' and $25^0$27' to $43^0$38' and $25^0$30'), which are situated in State Forest Enterprise Svishtov. There total area is about 612 ha, from which 92% is covered with vegetation (forest management plan of State Forest Enterprise Svishtov, 1996).

The studied territory is in the Danube plain. The growing conditions of forest communities in the riparian lands and on islands depend on their situation towards the average level of the Danube and on the duration of annual spring floods (Penev et al., 1969). Typical peculiarity of the islands is the moisture excess, short growing period, sudden summer droughts in the upper soil layer and negative effect of ice-break in winter (Tchernyavski and Pavlov, 1955; Denev, 1966). The altitude above sea level is 17-22 m, the relief is more or less raised surface with steep banks. The raised parts of the relief are covered by sand. They are formed by alluvial soils and Vardim oak communities are mainly there.

Investigations were carried out in the period 1999-2004 in five sample plots (SP), which are situated as follows: three of them are on Vardim island - the first and second one are in the protected area Stariyat dub (The Old Oak), the third is in a fenced part under venerable *Q. robur* trees. The fourth and fifth SPs are on Malak Vardim island, one of them being in 55-year-old *Q. robur* plantation and the other one - in regenerated cutting.

The assessment of silvicultural-and-inventory indices in all five SPs in representative parts of the stands with sizes from 0,1 to 0,2 ha was carried out according to standard methods. The assessment of the undergrowth was made in measurement plots established according to even systematic excerpt. Some methodological instructions for the regeneration assessment, suggested by Stoyanova (1988) and Kostov (2000 b), were applied. The plots are with sizes 1x1 m or 2x2 m depending on the height of seedlings. The established undergrowth was re-calculated and represented in number per hectare and the number of germs was reduced to three. According to

Table 1. Stands properties

Caracteristicile arboretelor studiate

SP	Veget. storey	Species composition (%)	Canopy closure (%)	DBH range (cm)	Height range (m)	Age range (years)
1	1	*Q. robur* (95), *P. alba* (5), *S. alba*	90	50–110	22–30	120–200
	2	*U. laevis* (80), *F. americana* (10), *M. alba* (10)	20	10–20	7–18	10–30
2	1	*Q. robur* (100)	55	60–115	20–26	120–200
	2	*U. laevis* (70), *F. americana* (5), *P. communis* (15), *M. alba* (10)	15	10–30	6–20	10–70
3	1	*Q. robur* (100)	40	90–110	19–21	150
	2	*A. fruticosa* (90), *F. americana* (10)	10	1–2	1,5–2,5	1–4
4	1	*Q. robur* (95), *U. laevis* (5)	70	20–45	18–22	45–55
	2	*U. laevis* (95), *M. alba* (5)	15	10–20	6–15	10–25
5	1	*P. euroamericana* (70), *U. laevis* (20), *M. alba* (10)	95	3–15	3–7	5–8

its quality it is differentiated into two categories: normal (without visible damages) and suppressed (due to insufficient light, as well as damages caused by wild animals or abiotic factors).

3. RESULTS

The age of the stands varies between 120-200 years. Out of the SPs, the oldest *Q. robur* trees are at 250 years. In SPs 1 and 2 spots were observed, where 2 to 6 venerable Vardim oak trees occur. Table 1 represents the basic silvicultural-and-inventory indices of the investigated tree species.

Undergrowth of *Quercus robur* was established in all studied SPs (table 2). Its quantity is minimal in SP5 and maximal in SP3, where the predominating part is normal 2-year-old, well-lighted undergrowth. The canopy closure is optimal and the excellent oak regeneration is preceded by soil preparation, fencing and additional sowing of acorns after falling of the fruits. In the rest SPs oak seedlings are suppressed because of the high canopy of mother stands and the additional tree and shrub vegetation. The number of seedlings does not exceed 2500 in SP 2, where shading is less comapred to SPs 1, 4 and 5. In SP4 number of seedlings is small, which is explained with less fruit-bearing of the still young 55-year-old Vardim oak plantation.

Ulmus laevis is the tree species with the widest occurrence among the undergrowth of the local species. It is spread in all SPs. Maximal regeneration was observed in SP5 - 6000 numbers/ha. The distribution of *Ulmus laevis* Pall. in the regenerated territories is single or in small groups.

Undergrowth of ***Populus alba*** was established on small area in SP1. The regeneration of this species is connected with decaying of single mature trees and following activating of root coppice-producing capability.

Table 2: Characteristic of the regeneration

Structura regenerării

SP	Species composition (%)	Coverage (%)	Height range (m)	Number/ha	Age range (years)	Quality
	Q. robur	under 1	0,2–0,6	1000	1–6	Suppressed
	U. laevis	6	0,5–4,0	4500	1–10	Normal
	F. americana	2	0,4–3,0	700	1–7	Suppressed
1	*P. alba*	1	1,5–3,0	100	1–2	Suppressed
	P. communis	–	1,0–3,0	500	1–7	Suppressed
	C. sanguinea	2	0,5–2,0	1500	1–5	Normal
	A. fruticosa	3	1,0–2,0	1000	1–5	Suppressed
	Q. robur	2	0,2–2,0	2500	1–8	Suppressed
	U. laevis	8	0,5–3,0	5000	1–12	Normal
	F. americana	2	0,4–2,0	1500	1–5	Normal
2	*M. alba*	1	0,5–2,0	5000	1–10	Normal
	P. communis	1	1,0–2,5	300	1–4	Normal
	A. negundo	–	1,0–3,5	50	1–3	Normal
	A. fruticosa	4	0,3–3,0	3500	1–7	Suppressed
	C. sanguinea	1	1,0–2,5	2000	1–5	Suppressed
	Q. robur	70	0,2–0,5	85000	1–3	Normal
	U. laevis	8	0,5–1,5	3500	1–4	Normal
3	*F. americana*	5	0,5–1,5	2500	1–4	Normal
	M. alba	2	0,5–1,5	1500	1–4	Normal
	A. fruticosa	5	1,0–1,5	7500	1–5	Normal
	Q. robur	under 1	0,1–0,4	200	1–5	Suppressed
	U. laevis	4	0,5–7,0	3500	1–10	Normal
4	*M. alba*	1	0,5–6,0	500	1–10	Normal
	F. americana	–	0,5–2,0	200	1–5	Suppressed
	A. fruticosa	1	0,3–2,5	800	1–5	Suppressed
	V. sylvestris	–	0,5–1,5	20	1–2	Suppressed
	Q. robur	single	0,2–0,7	30	1–3	Suppressed
	U. laevis	8	0,5–6,0	6000	1–5	Normal
	F. americana	2	1,0–5,0	1500	1–5	Normal
5	*M. alba*	–	0,5–7,0	400	1–5	Normal
	A. negundo	–	0,5–2,5	50	1–4	Normal
	A. fruticosa	30	1,5–3,0	14500	3–5	Normal

Undergrowth of *Morus alba*, although widely spread, is with low concentration. It is suppressed in all SPs, where it is observed. The possibilities for natural regeneration of this valuable forest-fruit tree species are insignificant.

Regeneration with *Amorpha fruticosa* on Vardim and Malak Vardim islands is total. After clear cuttings and uprooting of poplar plantations, its massive spreading is observed.

Undergrowth *Fraxinus americana* was established in all SPs in quantities very close to these ones of *Ulmus laevis*. As a whole its distribution is overall. It is evenly spread on huge areas with trend to increase the occupied territories. The young *Fraxinus americana* trees are fast-growing. Compared to *Amorpha fruticosa, Fraxinus americana* has the bigger regeneration potential and it is more capable to invade forest areas abandoned after cutting of hybrid poplars.

Undergrowth of *Acer negundo* was established in two of the SPs and its

number was small. Together with *Fraxinus americana*, these are one of the strongest competitors of the local tree species. It is quite possible that they could replace the autochthonous stands in the future, which would bring to loss of genetic fund.

4. DISCUSSION

Adequate and administrative and silvicultural measures are necessary for the preservation of Vardim oak forests. While the first ones are on advanced and satisfactory stage, the second ones are far behind. The most serious problem of the Vardim oak is that it is ageing and its natural regeneration is poor. Although not very intensive, a process of decaying of old trees (200-250 years of age) is observed. The age of Vardim oak is far from the limit, shown for Bulgaria by Efremov et al. (2000). Due to the high moisture of Vardim sites it is possible that the limit age of these venerable trees does not exceed 250 years. Species like *Ulmus laevis, Fraxinus americana, Amorpha fruticosa*, etc. spread under the oak forest canopy and additionally prevent the occurrence of *Quercus robur* seedlings. Interesting fact about Vardim islands is that there are almost no oak trees at the age of 25-90. It is also rare to find young trees and undergrowth between 10 and 20 years of age. In fact, acorns and seedlings survived very difficult due to the grazing of numerous flocks of cows, sheep, domestic pigs and horses (Petkov, 1940; Tchernyavski and Pavlov1955; Denev 1968). Until 1960, Vardim oak undergrowth occurred sporadically and disappeared without leaving even a single seedling. In 1960 Denev (1968) established excellently regenerated areas of *Q. robur* after advanced soil scarification. In two of all four experimental plots the author counted about 500,000 seedlings per hectare. Similar results have been obtained by Bobinac (2000) in natural Slavonian oak reserves in Vojvodina (Serbia). According to this author, by abundant fruit bearing the regeneration of *Q. robur* could reach in certain places 100-150,000 numbers/ha, even 400,000 numbers/ha.

The 85,000 numbers/ha (SP3), established in this work, are comparable, as quantity, with that of the authors mentioned above. The conditions in this SP have been optimal for the excellent oak regeneration. It is of great importance to plough in advance and to stop the grazing in the regeneration section. Predominantly wild swine and to a less extent steppe deer have been observed there during the last 10 years. In Bulgaria, the opinions about harms and benefits from grazing of *Sus scrofa* L. are contradictory. According to Damyanov (1910), "wild swine could also have big benefit for the forest. They scarify soil, make it capable for sowing of seeds, exterminate mice, insects, their larvae and fungi". On the other hand, the author recommends forbidding grazing 3-4 years prior to cutting, to provide natural regeneration. Stoyanov (1935) thinks that mature stands must be maintained clear from ash and elm trees during oak regeneration. This could be done with the help of swine, "which prevent the soil to get wild through their wandering and rooting about". The opposite thesis about harm and benefit from grazing of domestic and wild animals for oak undergrowth on Danube islands and Longoza forests is determined, among others, by Stoyanov (1933), Petkov

(1940), Tchernyavski and Pavlov (1955), Kostov (2000).

It was established by one of the observations from 2002, that the fence in SP3 has been destroyed. Wild swine grazed unimpeded in the regeneration area and had destroyed the *Q. robur* undergrowth. Only single seedlings had survived; in this case the harm was obvious. In general, the grazing of the wild animals have the same consequences as of domestic ones. After abundant fruit bearing the acorns are almost 100% destroyed. In SP2, the conditions were relatively suitable for the development of oak seedlings. In 1999 and 2002, good fruit bearing was observed. In 2004 regeneration was unsatisfactory, again due to grazing.

Zahariev (1938) mentions that abundant fruit-bearing years for *Q. robur* in plains of Southern Romania are repeated relatively rarely, every 10-12 years. Bobinac (2000) has even the opinion that regeneration cycles in old Slavonian forests are after a long period of 25-50 years. Regeneration is possible under the influence of a complex of favourable factors - abundant fruit bearing, optimal water regime, restricted grazing, enough long growing period, normal lighting of undergrowth. The advanced support of natural regeneration, combined with soil preparation, is a guarantee for the success of *Q. robur* forests (Zahariev, 1938; Denev, 1968). Petkov (1940) claims that if the oak forests are free from grazing and soil is scarified, the regeneration results will be very good. The author recommends artificial and natural ways of support and describes establishing of *Q. robur* plantations near the village of Vardim and Belene island. Some single trees have survived until today. Later on, new areas have been afforested near the town of Svishtov and village of Dzhulyunitsa (Denev, 1972, 1976), on islands Vardim, Kovatchev, etc.

Good results, which have been already obtained in afforestations and the return of *Q. robur* on Vardim islands show that a good preparation is necessary, as well as durable maintenance and protection of young oak plantations. Due to the restriction maintenance regime in the protected territory, which is a very close to that of the reserves, carrying out of regenerating cuttings is currently difficult. The entire fencing of these forests is very expensive activity. There, the regeneration will not be successful without reducing the canopy closure and without applying intensive support. Fencing of single or small groups of fruit-bearing oak trees and establishing of small regeneration sections is an alternative for the fencing of huge areas. This approach has the following priorities: (i) every year the whole acorn will be utilized. Partial fruit bearing is observed on Vardim island every 2-3 years and single oak trees give yield almost every year; (ii) seedlings will be available, which will be used in other places and meanwhile the afforestation period will be extended with another 1-2 years; (iii) after growing up of seedlings in the regeneration centre, the fence could be moved to another section.

In the future, the afforestation as well as the pointed out measures for undergrowth preservation in regenerating oak sections, should continue, in order to preserve the forest treasure of Vardim.

5. CONCLUSION

Regeneration processes observed on the investigated islands are very peculiar. On one hand, *Ulmus laevis* has good regeneration potential and to less extent - *Q. robur*. On the other hand, the introduced *Amorpha fruticosa* and *Fraxinus americana* self-spread in large scales. Grazing of wild animals and first of all of *Sus scrofa* is considered to be the basic reason for the unsatisfactory oak regeneration. It is recommended that fences to be made for the successful natural regeneration of *Q. robur*. To prevent the further invasion of the introduced tree species, an increase of the participation of local tree species and of the conservation value of Vardim islands, it is necessary, because: (i) reafforestations with hybrid Euroamerican poplars and other exotic tree species are no longer performed; (ii) clear cuttings in forests composed by native tree and shrub species are no longer performed; (iii) regeneration groups of *Quercus robur, Ulmus laevis., Populus alba, Populus nigra* and *Salix alba* are established. This could be done by supporting the natural regeneration or by reafforestation with Vardim reproductive materials.

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