Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VII, 2018
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

OAK SPECIES – PROVIDING RENEWABLE AND SUSTAINABLE RAW MATERIALS, ENRICHING THE ECOSYSTEMS SERVICES AND FULFILLING THE SOCIAL DEMANDS. CASE-STUDY – WESTERN ROMANIA

Adrian Mihai OPREA, Gheorghe Florian BORLEA, Dorel DRONCA

"King Michael I[st] of Romania" Banat's University of Agricultural Sciences and Veterinary Medicine, 119 Aradului St, Timisoara, Romania

Corresponding author email: admihao@yahoo.com

Abstract

Oak wood has been highly praised since the Middle Ages for its strength and durability. This is one of the densest naturally occurring materials; it has good folding qualities despite its natural durability and has a high tannin content which makes it resistant to insects and pests. It is durable, impregnates easily, resists moisture absorption and thanks to its aesthetics and resistance, it is recommended as an excellent feedstock for the furniture industry and beyond, it is often used to manufacture floors, stairs, exterior and interior joinery, interior architectural elements, natural or stained plywood, boards, tiles, ornaments turners, profiles, barrels and it should be continuously promoted because it is a renewable and sustainable raw material. The oak stands have a significant position in the Romanian forests (18% of the country's total forest area) and in the European ones; they are perhaps more appreciated now than in the past, not only for the particular structural qualities of the wood, but also because they contribute to the biological wealth of the forest ecosystems and for how they participate to the conservation of biodiversity creating an environment that helps to fulfil the social demands. Due to the present-day high market demand, the recent wood industry development and the multiple available transport options, oak wood is imported and exported at a high rate. It would be desirable to promote only those oak raw materials which originate from certified forest areas which are sustainably managed, where forest ecosystem services as well as certified wood chains of custody are promoted. That is why we need to identify, study and monitor the areas which are suitable for obtaining valuable forest stands with Quercus robur (pedunculate oak), Quercus petraea (sessile oak) or Quercus frainetto (Italian oak), and to ensure their growth by applying a sustainable forest management.

Key words: *oak species, sustainable forest management, renewable raw material, ecosystem services.*

INTRODUCTION

From ancient times, wood has been one of the most used raw materials, probably because it is one of the first natural resources that humans learned to use.

Wood and wood products are recommended because they are durable, versatile and strong; it can be transformed into all kinds of shapes and sizes, being a renewable and environmentally friendly product.

It is important to consider that the forests regulate the quality of air and water, contribute to soil formation, provide protection from erosion and mitigate climate change through carbon sequestration (wood carries the lowest carbon footprint of any comparable building material).

According to FAO 2006, around 4,000 million ha, the equivalent of around 30% of the earth's land area, is covered by forests. About 3,000 million m^3 are harvested worldwide annually, of which around 60% are used as industrial round wood and 40% as fuel wood. According to the study "Use of renewable raw materials with special emphasis on chemical industry", performed by the European Topic Centre on Sustainable Consumption and Production, it is stated that "wood is likely to be the oldest and quantitatively the biggest raw material sector from renewable sources" (Jering and Günther, 2010).

The most used wood species all over the world along history are oaks. Compared to wood provided by other tree species, oak species wood is generally light colored with a prominent grain and has a high resistance to fungal attacks. It is one of the densest naturally occurring materials and it has been praised for its strength and durability since the Middle Ages. Oak barrels were the first choice for storing and transport of liquids like water and

alcohol. The majority of the wooden boats, used for transport, were also made of oak wood, "at least 50-60% of all wooden ships were made of oak" (Agnoletti and Anderson, 2002). It was used as a building material since the beginning of human civilization, "being second only to stone in terms of its rich and storied history in the world of construction" (Agnoletti and Anderson, 2002). This exceptionally versatile material was commonly used to build shelters and houses ("the structural beams and much of the woodwork in Europe's finest and oldest remaining churches and castles are made from oak"), "throughout the whole of the medieval period, oak dominated the field of construction on the basis of both its durability and its general availability. While much of this building stock has been lost, a significant number survive today, some five hundred years or so after they were built" (Ross et al., 2007).

In the 1960s, due to the trends in the furniture market, the demand for pedunculate oak and sessile oak wood began to increase, as this wood has special qualities for as aesthetic veneer (Badea et al., 1960). In their paper "Contribution to the Study of oak trees stands, suitable for the production of aesthetic veneers," they mention that the studies carried out in Romania showed that there are a significant number of trees from which such material could be obtained, but expressed their concern that "increased demand could be a futile tendency that would speed up the harvesting of oak trees stands".

Taking a look at the recent period we can observe that nowadays oak wood is very extensively used in the furniture and home decor industry, as it is also presented in the FAO and Forest and Timber Section of the UNECE statistics (www.unece.org).

In order to enhance the carbon sequestration it is important to promote wood as a sustainable and renewable material not only in the construction industry but also in interior design. In the paper "Environmentally sustainable interior design: A snapshot of current supply of and demand for green, sustainable or Fair Trade products for interior design practice" (Hayles, 2015), it is stated that "by integrating environmentally sustainable materials into building projects, it is possible to significantly reduce environmental impacts through lower energy consumption, lower natural resource depletion and pollution, and lower toxicity for both the occupants and the entire ecosystem. These both minimize the negative impacts on the environment and occupants while maximizing positive impacts over the lifecycle of a building." Many other authors support this view (Araji and Shakour, 2013; Kang and Guerin, 2009).

The concept of ecosystem services, meaning the benefits society obtains from ecosystems, has gained widespread acceptance among scientists, managers and politicians since its use in the Millenium Ecosystem Assessment (2005). Trees, woods and forests provide direct products (timber, fuel, food, and game), direct cultural services (recreation, aesthetic, and landscape, historic and cultural values) and indirect regulating services (air and water quality, mitigation of climate change, soil protection). All these products and services contribute to human well-being (Cranford and Mourato, 2011; Cuperus et al., 2001; Engel et al., 2008; FAO, 2010).

The European Commission stated that "today, forests cover nearly 40% of the European surface and are home to much of the continent's biodiversity. In addition to the supply of wood, to which most forested European land is dedicated, forests provide a multitude of benefits in terms of climate regulation, human health, recreation, refuges, fresh water supply and many others" (http://forest.jrc.ec.europa.eu).

"Forests play a crucial role in providing multiple benefits for citizens. They deliver forest products and many other ecosystem services (recreation, clean air and water, biodiversity, scenic and cultural values). Moreover, forests contribute to job creation and economic growth" (EUSTAFOR, 2018). Forests, especially oak ones, are a gateway for hunters and fishermen. But they are also a treasure for outdoor enthusiasts who are searching for adventures and recreation and want to improve their physical and psychological well-being.

The study "Oak trees and woodlands providing ecosystem services in Southern Spain" concludes that the "urban populations are increasing their demand for cultural services

coming from woodlands, mainly for recreation, ecotourism and for their aesthetic and spiritual values" (Marañón et al., 2012). The abandonment of rural areas leads to a loss of cultural local knowledge but this has changed in the last decades.

"When forests are sustainably managed, their biodiversity, productivity, regeneration capacity and vitality are maintained while leaving all interconnected ecosystems intact and fulfilling relevant ecological, economic and social functions" (Thomsen, 2016).

Forests which are not well managed are often unhealthy and unproductive because of overcrowding, disease, insects, and competition for light, water and nutrients. To maintain or improve the health and productivity of a forest, foresters use a number of management techniques that include harvesting (www.ncforestry.org). Harvesting and thinning operations should be encouraged because this type of forest management mimics natural dynamics and promotes tree species that would otherwise not have a chance to thrive (like oak ones, which tend to be overwhelmed by other species when found in the same composition).

In mixed closed canopy forests, oak regeneration is often poor below the canopy (Gotmark, 2007) and the mixed species like hornbeam, acacia or lime, that normally should have a helpful role when found in the same composition with oaks, in fact they tend to replace oak seedling in absolute natural conditions the oak manages to maintain and win the competition with mixed species and, foremost because it has an extraordinary longevity (Pascovschi, 1967).

In order to provide the most adequate measures for a sustainable management of oak forests, we have started by studying the site and the forest types in the area where oak logs were harvested, trying to identify the main ecosystem driven factors which have contributed to the high quality of wood, meanwhile providing the ecosystem services. The obtained results would contribute to making further adequate forest management decisions which could influence the growth and the timber quality.

The present research main goal is to determine the site type characteristics which will favor oak stands to better grow and which will produce valuable wood as renewable and environmentally friendly material by sustainnable forest management at the end of a production cycle.

MATERIALS AND METHODS

A survey was conducted in Western Romania in the forest area managed by the State Forest Administration "Romsilva", Timis Forest Directorate, that has 77,436 hectares under management, administered through 6 Forest Districts (Forest District Ana Lugojana with an area of 11,722 ha, Forest District Cosava with an area of 18,584 ha, Forest District Faget with an area of 13,938 ha, Forest District Lugoj with an area of 12,042 ha, Forest District Lunca Timisului with an area of 9,674 ha and Forest District Timisoara with an area of 11,476 ha) that generate an allowable cut of approximately 250,000 cubic meters per year and have a diverse species distribution. Broadleaves cover an area of 71,224 ha (beech 25,544 ha, oaks 28,806 ha, hardwood 14,390 ha and softwood 2,484 ha), the rest of 4,608 ha being covered by evergreens (spruce 2,459 ha, fir 869 ha and other evergreens 1,280 ha).

In 2000 a system of biannual public auctions (in early spring and in late autumn) was introduced in the Western part of Romania (Arad and Timis Forest Directorate).

The present study is based on the results obtained at the above mentioned public auctions organized by the Timis Directorate between 2003 and 2017. A total of 7,772 oak logs, harvested from the six forest districts, were selected from the annual harvest resulting a total volume of high quality wood logs of 8,638 m^3 to be sold in the above-mentioned auctions.

Data regarding the provenance, the origin, the site type, the forest type as well as all the characteristics provided by the informational forestry system, as they are presented in the irrespective Forest Management Plans, were analyzed for all harvested and selected wood logs using Excel programme.

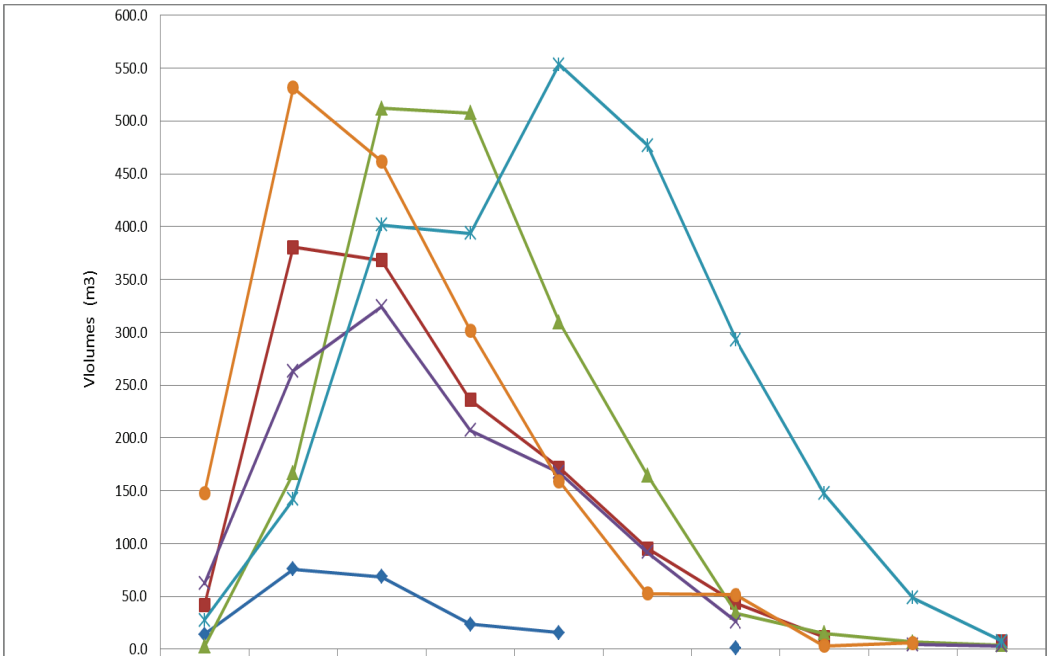
RESULTS AND DISCUSSIONS

By performing harvesting and thinning operations, which were done by the employees of the forest district or by contractors, operations that open up the forest canopy, allowing more light

to reach down through the lower levels of the forest, encouraging dormant seeds to germinate and providing light for plants to grow, that strictly followed the management plan in the period between 2003 to 2017 on the forest surface administered by Timis Forest Directorate, resulted in high quality logs of *Q. robur, Q. petraea and Q.frainetto*. The resulting wood logs have had special characteristics and after proper sorting, superior industrial quality sortiments (veneer logs, logs for barrels, sawmill logs used for furniture production or for parquet production) were sold at open public auctions at prices ranging from 100 to 1200 euro/m^3.

The State Forest Administration "Romsilva" promotes only those oak raw materials which originate from certified forest areas which are sustainably managed, where forest ecosystem services as well as certified wood chains of custody are obtained. Therefore for each log which was included in the study, the place of origin could be determined.

It was assumed that the selling price of the logs reflects the quality of the wood material obtained at the end of a production cycle. In order to be ranked according to their financial value, the logs have been classified into 10 price series from 100 euro/m^3 to 1200 euro/m^3.

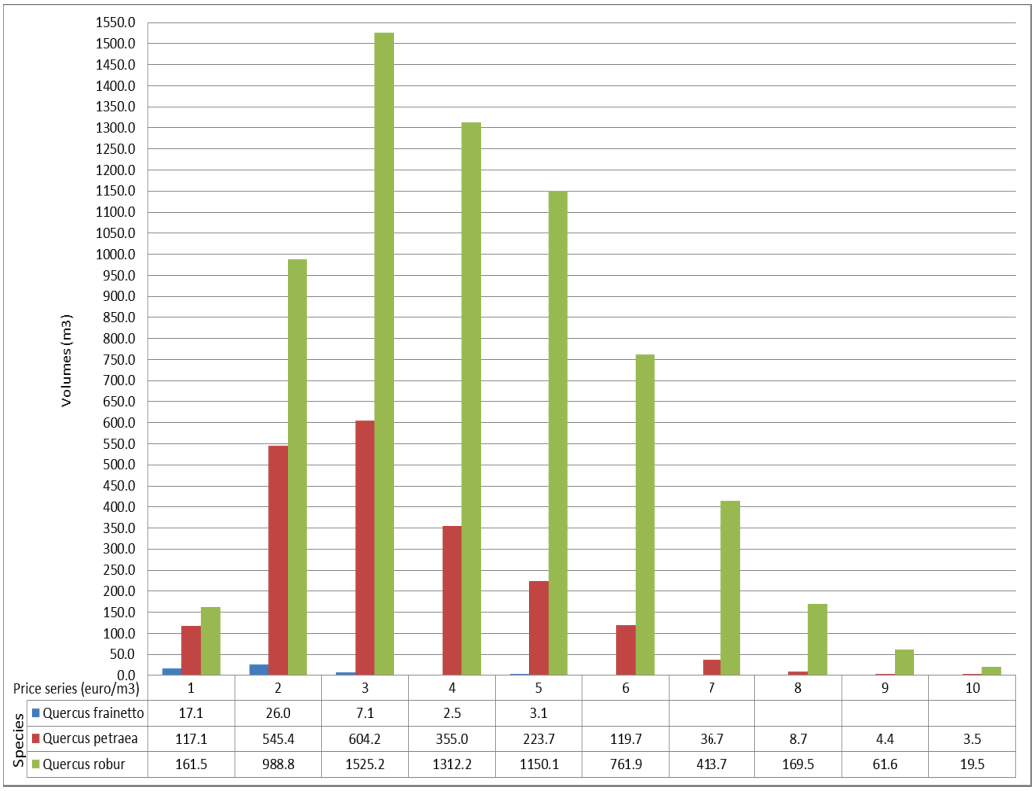


Forest District / Price series (euro/m3)	1	2	3	4	5	6	7	8	9	10
Ana Lugojana	14.3	75.9	68.6	23.7	15.6		1.4			
Cosava	41.8	380.5	368.3	235.9	172.0	95.6	43.8	11.8		7.8
Faget	2.5	166.7	512.0	507.8	309.5	164.6	34.5	15.5	6.9	4.0
Lugoj	62.2	263.5	324.3	207.1	167.5	91.8	26.2		4.4	3.5
Lunca Timisului	27.5	142.1	401.5	393.7	553.3	477.0	292.9	147.4	48.7	7.7
Timisoara	147.4	531.5	461.9	301.5	158.9	52.6	51.6	3.5	6.0	

Figure 1. Price series (euro/m^3) obtained in oak wood logs auctions in 6 forest districts from the State Forest Administration "Romsilva" - Timis Forest Directorate, in the period 2003-2017

Analyzing the collected data, it can be concluded that the biggest volume of oak wood sold in the auctions are found in the third (300-399 euro/m^3) and fourth (400-499 euro/m^3) price series. It can also be observed that the biggest high quality oak wood volume comes from the Lunca Timisului Forest District, which is located in a plain area (1,534 logs of

pedunculate oak and 1 log of Italian oak, amounting a total volume of 2,491.7 m^3), closely followed by the Timisoara Forest District, which has under administration forests located in the plain and hilly area (1,357 logs of pedunculate oak, 547 logs of sessile oak and 36 logs of Italian oak with a total volume of 1,715.1 m^3); then Faget Forest District (1,109 logs of pedunculate oak, 425 logs of sessile oak and 1 log of Italian oak amounting a total volume of 1,715.1 m^3) and Cosava Forest District (997 logs of pedunculate oak, 450 logs of sessile oak and 5 logs of Italian oak, with a total volume of 1,357.4 m^3), both districts (Faget and Cosava) having under administration forests located in the hilly and mountainous area; followed by Lugoj Forest District (528 logs of pedunculate oak, 547 logs of sessile oak and 33 logs of Italian oak with a total volume of 1,150.4 m^3) which has under administration forests located in the plain and hilly area and the last one - Ana Lugojana Forest District, which has under administration forests located in the mountainous area (202 logs of sessile oak amounting a volume of 199.5 m^3).



Price series (euro/m3)	1	2	3	4	5	6	7	8	9	10
Species: Quercus frainetto	17.1	26.0	7.1	2.5	3.1					
Quercus petraea	117.1	545.4	604.2	355.0	223.7	119.7	36.7	8.7	4.4	3.5
Quercus robur	161.5	988.8	1525.2	1312.2	1150.1	761.9	413.7	169.5	61.6	19.5

Figure 2. Price series (euro/m^3/species) obtained for *Q. robur, Q. petraea and Q. frainetto* in wood logs auctions in 6 forest districts from the State Forest Administration "Romsilva" - Timis Forest Directorate, in the period 2003-2017

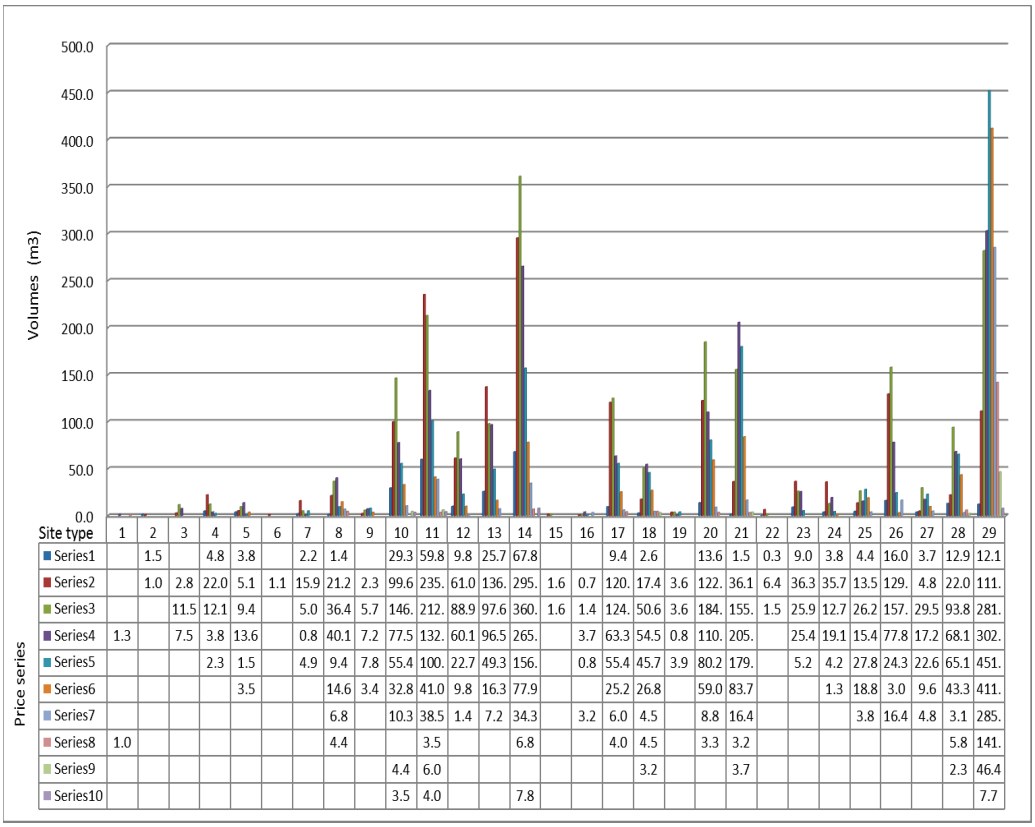
It can be observed (Figure 2) that in the upper price categories, that are generally represented by logs of superior quality, pedunculate oak logs are the main part (71% from the total number of logs and 76% of the total logs volume) followed by the sessile oak (28% from the total number of logs and 23% of the total volume.

The Italian oak represents 1% from the total number of logs and from the total volume.

Twenty nine site types have been identified where the oak logs were harvested from (the site types names are in accordance with the classification used in the informational system for forestry in Romania as it is used in the Forest management plans, Table 1).

Table 1. Site types where the high quality oak species logs were harvested between 2003-2016 in the State Forest Administration "Romsilva" - Timis Forest Directorate

Forest Types	Site Type	Site Type nr.	Site Type code	Main characteristics of the Site Type		Volume (m3)
				Soil	Flora	
Mountain F. types	Beech Forest site type	1	4430	rocky with excessive erosion		2.3
Hill and Plateau Forest types	Sessile oak Forest site type	2	5132	Argiluvisols, Eluviated brown soil, podzol	Mezofit grasses	2.5
		3	5142		Carex Pilosa	21.8
		4	5152		Asperula-Asarum	45.0
		5	5153		Asarum-Stellaria	37.0
	Beech Forests site types	6	5231		Vaccinium-Luzula	1.1
		7	5242	Cambisol, Brown eu-mesobasic soil, molic	Asperula-Asarum	28.7
		8	5243			134.3
	Sessile oak and mixed oak Forest Site Types	9	6131	Argiluvisol, Argilic iluvial brown soil, podzol	Acidofil mezoxerofit	26.4
		10	6132		mezoxerofit grasses	459.0
		11	6142	Argiluvisols, Eluviated brown soil, pseudogleyic, Argilic iluvial brown soil	Carex pilosa Carex – Poa pratensis	833.9
		12	6143			253.8
		13	6152	Argiluvisol, Argilic iluvial brown soil	Aserum Stelaria, Carex – Poa pratensis	429.5
		14	6153			1272.0
		15	6241	Argiluvisols, Eluviated brown soil, pseudogleyic,	Carex pilosa	3.2
		16	6251	Cambisol, Brown eu-mesobasic soil, tipical	Festuca altissime	9.8
		17	6252		Asperula-Asarum	408.1
		18	6253		Asperula-Asarum	209.9
		19	6264		Carex brisoides -Argostis alba	11.8
	Pedunculate oak and mixed oak species Forest site type	20	7332	Argiluvisols, Eluviated brown soil, pseudogleyic	Poa pratensis Carex caryphyllea	581.8
		21	7333		Carex – Poa pratensis Brachypodium-Geum	684.8
		22	7334	Argiluvisol, Argilic iluvial brown soil	Carex – Poa pratensis	8.2
		23	7430		Brachypodium-Geum-Pulmonaria	101.9
		24	7530			76.9
Plain Forest types	Oak and mixt Forest site types	25	8332	Argiluvisol, Eluviated brown soil, pseudogleyic	Carex brisoides -Argostis alba	109.9
		26	8333	Argiluvisols, Eluviated brown soil, molic-redzinic	Arum-Pulmonaria Rubus caesisus –Aeg.	424.3
		27	8335	Argiluvisols, Levigated reddish brown soils, pseudogleyic	Arum-Pulmonaria	92.2
	Oak river bench site types	28	8511	Argiluvisols, Redish brown forest soil, humid, gleyic or semi-gleyic,	Brachypodium-Geum-Pulmonaria	316.4
		29	8512	Argiluvisols, Redish brown forest soil, humid, gleyic or semi-gleyic, molic		2051.8



Price series / Site type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Series1		1.5		4.8	3.8		2.2	1.4		29.3	59.8	9.8	25.7	67.8			9.4	2.6		13.6	1.5	0.3	9.0	3.8	4.4	16.0	3.7	12.9	12.1
Series2		1.0	2.8	22.0	5.1	1.1	15.9	21.2	2.3	99.6	235.	61.0	136.	295.	1.6	0.7	120.	17.4	3.6	122.	36.1	6.4	36.3	35.7	13.5	129.	4.8	22.0	111.
Series3			11.5	12.1	9.4		5.0	36.4	5.7	146.	212.	88.9	97.6	360.	1.6	1.4	124.	50.6	3.6	184.	155.	1.5	25.9	12.7	26.2	157.	29.5	93.8	281.
Series4	1.3		7.5	3.8	13.6		0.8	40.1	7.2	77.5	132.	60.1	96.5	265.		3.7	63.3	54.5	0.8	110.	205.		25.4	19.1	15.4	77.8	17.2	68.1	302.
Series5				2.3	1.5		4.9	9.4	7.8	55.4	100.	22.7	49.3	156.		0.8	55.4	45.7	3.9	80.2	179.		5.2	4.2	27.8	24.3	22.6	65.1	451.
Series6					3.5			14.6	3.4	32.8	41.0	9.8	16.3	77.9			25.2	26.8		59.0	83.7			1.3	18.8	3.0	9.6	43.3	411.
Series7								6.8		10.3	38.5	1.4	7.2	34.3		3.2	6.0	4.5		8.8	16.4				3.8	16.4	4.8	3.1	285.
Series8	1.0							4.4			3.5			6.8			4.0	4.5		3.3	3.2							5.8	141.
Series9										4.4	6.0							3.2			3.7							2.3	46.4
Series10										3.5	4.0			7.8															7.7

Figure 3. The relation between volumes of harvested wood (m^3), site type and price series in euro/m^3 (results from the wood auctions in 6 forest districts from the State Forest Administration "Romsilva" - Timis Forest Directorate, in the period 2003-2017)

It can be observed that the biggest volume, 2,051.8 m^3, (23.8% of the total volume taken into account in the study) can be found in the Site Type 8512 (nr. 29). At the same time we can see that the upper price series, that are generally represented by logs of superior quality, are mostly found in Site Type 8512 (33.3% of the 10th price series volume, 70.3% of the 9th price series volume, 79.5% of the 8th price series volume, 69.3% of the 7th price series volume, 46.7% of the 6th price series volume, 32.8% of the 5th price series volume, 18.1% of the 4th price series volume, 13.2% of the 3rd price series volume, 7.1% of the 2nd price series volume and 4.1% of the 1st price series volume).

The second most representative is Site Type 6153 (nr. 14) with a volume of 1,272 m^3 (14.7% of the total volume taken into account in the study) in which the upper price series are found but also lower price series are well represented (34% of the 10th price series volume, 3.8% of the 8th price series volume, 7.62% of the 7th price series volume, 8.84% of the 6th price series volume, 11.4% of the 5th price series volume, 15.9% of the 4th price series volume, 16.9% of the 3rd price series volume, 18.9% of the 2nd price series volume and 22.9% of the 1st price series volume).

The third most representative is Site Type 6142 (nr. 11) with a volume of 834 m^3 (9.7% of the total volume taken into account in the study) in which all the price series are found (17.6% of the 10th price series volume, 9.1% of the 9th price series volume, 2% of the 8th price series volume, 8.5% of the 7th price series volume, 4.6% of the 6th price series volume, 7.3% of the 5th price series volume, 8% of the 4th price series volume, 10% of the 3rd price series

volume, 15.1% of the 2nd price series volume and 20.1% of the 1st price series volume).

DISCUSSIONS

Forests are an important part of our life, providing ecosystems services, fulfilling social demands and contributing to the economy by providing renewable and sustainable raw materials. "The unexploited potential in terms of the wood and non-wood products and services provided by European forests is outstanding" (Borkowski and Langue, 2018).
The replacement of valuable *Quercus* sp. by low-value mixed species has negative effects both ecologically - causing major changes in forest ecosystems, and economically - reducing the value of wood produced at the end of a production cycle (pedunculate and sessile oaks, or even Italian oak, produce wood with special structural qualities which can be sold at prices 5-6 times higher than the wood of hornbeam, acacia or lime).
Taking into consideration the field conditions, appropriate silvicultural techniques must be applied in order to achieve a composition in which oaks are predominant and, once they reach the age of exploitability, they will provide timber as valuable as that originally harvested. In the study “Silviculture of Oak for High-Quality Wood Production” it is stated that silviculture based on early initiated, heavy thinning for obtaining the 'best' trees at regular intervals (Attocchi, 2015).
Identifying the areas which are favorable for valuable forest stands with of oak species; we can promote to the market only those oak raw materials which originate from certified forest areas which are sustainably managed, where forest ecosystem services as well as certified wood chains of custody are obtained.
Site types and stand factors which will favor oak stands to grow and produce valuable sustainable and renewable materials at the end of a production cycle should be identified and studied (Annighöfer et al., 2015).

CONCLUSIONS

The market demand for high quality wood logs of oak species (*Q. robur, Q. petraea* and *Q. frainetto*) in Western Romania has continuously been growing in the last decade, as well as their sale price in public auctions organized by State Forest Administration "Romsilva" - Timis Forest Directorate between the years 2003 – 2017.
The site type characteristics are an important driven factor for obtaining high quality oak wood. Analyzing the harvesting area, twenty nine site types have been identified for the above mentioned high quality oak wood logs, the results leading to the conclusion that the most suitable site types for obtaining oak species logs of superior quality are: 8512, 6153 and 6142.
The highest quality oak species logs were obtained in Western Romania in the last decade in the plain area which is characterized by rich Argiluvisols like Redish brown forest soil (humid, gleyic or semi-gleyic), Argilic iluvial brown soil and Eluviated brown soil, (pseudogleyic) with appropriate water regime.
Silvicultural measures which will combine the adequate intensive forestry measures based on recent field observations and studies to promote the most valuable oak species (pedunculate oak, sessile oak and also Italian oak) in relation with their ecological requirements, are the solution for the sustainable management of oak forests in Western Romania: big volumes of high quality logs for the wood industry and economics and services for the benefit of the society. After more than 50 years of forest management in the research area, the conclusion is that this is not a futile tendency. Oak stands are of significant importance in Romanian and all European forests. They are perhaps even more appreciated than in the past, not only for the particular structural qualities of their wood, but also more and more for the contributions that these species bring to ecosystem services.

REFERENCES

Agnoletti M. and Anderson S., 2002. Forest History - International studies on socio-economic and forest ecosystems change; Wallingford, Oxon: Report n.2 of the IUFRO Task Force on Environmental Change, CAB International Publishing.

Annighöfer P., 2015. Regeneration Patterns of European Oak Species (*Quercus petraea* (Matt.) Liebl., *Quercus robur* L.) in Dependence of Environment and Neighborhood. Plos One, 10(8): 1-16p.

Araji, M.T., Shakour, S.A., 2013. Realizing the environmental impact of soft materials: criteria for utilization and design specification. Mater. Des. 43: 560–571.

Attocchi G., 2015. Silviculture of Oak for High-Quality Wood Production, Effects of thinning on crown size, volume growth and stem quality in evenaged stands of pedunculate oak (*Quercus robur* L.) in Northern Europe. Acta Universitatis Agriculturae Sueciae. 39 : 86.

Badea M., 1960. Contribution to the Study of oak trees stands, suitable for the production of aesthetic veneers. Analele ICAS. 28 : 251-269.

Borkowski P. and Langue F. L., 2018. International Day of Forests 2018: EuropFean forests can deliver even more benefits to society; www.eustafor.eu/international-day-of-forests-2018-european-forests-can-deliver-even-more-benefits-to-society.

Cranford M., Mourato S., 2011. Community conservation and a two-stage approach to payments for ecosystem services. Ecological Economics. 71: 89–98.

Cuperus, 2001. Ecological compensation in Dutch highway planning. Journal of Environmental Management. 27(1): 75-89.

Engel S., Pagiola S. & Wunder S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological economics. 65: 663-674.

European Commission (http://forest.jrc.ec.europa.eu).

European State Forest Association, 2018. International Day of Forests 2018: European forests can deliver even more benefits to society. www.eustafor.eu.

Forest Europe report, 2015. The State of Europe's Forests; http://foresteurope.org/state-europes-forests-2015-report/.

Food and Agriculture Organization of the United Nations, 2010. Payments for environmental services within the context of the green economy. http://www.fao.org/docrep/013/al922e/al922e00.pdf..

Gotmark F., 2007. Careful partial harvesting in conservation stands and retention of large oaks favour oak regeneration. Biological Conservation. 140: 349-358.

Hayles C. S., 2015. Environmentally sustainable interior design: A snapshot of current supply of and demand for green, sustainable or Fair Trade products for interior design practice. International Journal of Sustainable Built Environmentn. 4 : 100-108.

Jering A. and Günther J., 2010. European Topic Centre on Sustainable Consumption and Production Report – Use of renewable raw materials with special emphasis on chemical industry; ETC/SCP report 1/ 2010.

Kang M., Guerin D.A., 2009. The characteristics of interior designers who practice environmentally sustainable interior design. Environ. Behav. 41 (2): 170–184.

Marañón T., Ibáñez B., Anaya-Romero M., Muñoz-Rojas M. and Pérez-Ramos I. M., 2012. Oak trees and woodlands providing ecosystem services in Southern Spain. Trees beyond the wood - Conference proceedings. 369-378.

Millenium Ecosystem Assessment (MEA), 2005. www.millenniumassessment.org.

North Carolina Forestry association www.ncforestry.org.

Pascovschi S. and Donita N., 1967. Vegetatia lemnoasa din silvostepa Romaniei; Editura Ceres, pp. 175.

Ross P., Mettem C. and Holloway A., 2007. Green oak in construction; TRADA Technology Ltd. 2007. www.trada.co.uk.

Thomsen G., 2016. Managing European Forests Responsibly – for People, Climate and Nature, Revolve magazine. 19: 10-15.