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**OPTIMIZATION OF OAK TREE
STANDS GROWING IN
CONDITIONS OF VINNYTSIA
REGION**

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The main part of forest plantations of Vinnytsia region is occupied by plantations with predominance of pedunculated oak (81%).

Most of oak stands that grow within the region, in terms of plantings composition, correspond to the types of forest plant conditions. Under those circumstances, most tree species show high growth rates. The area of plantations of the II class quality makes up 94.7%, 4.9% – of the III class quality and 0.4% – of the IV. The largest area (57.1%) is occupied by plantations with the density of 0.7, slightly smaller (31.8%) – with the density of 0.8, and plantations with the density of 0.9 to 1 occupy the area of 3.5%, with the density of 0.6 – 6.3%; 0.5 – 0.8%; 0.4 – 0.3%. Despite the systematic intermediate cutting, which was carried out in order to preserve the pedunculated oak, European ash and other valuable species as a part of 92-132-year-old stands, the highest number of the preserved trees belongs to hornbeam (36.5-64.9% of the total number were in 19 plantations of Vinnytsia region). Only on two plantations 9.7-14.9% of hornbeam out of the total number of tree species was found.

According to biological and ecological properties, the optimum proportion of European ash in plantation is 25-30% of the total number of trees provided they are evenly distributed over the area. According to the research conducted, there was no ash trees in two stands, in one plantation only eight trees of ash were preserved, in the next three – 100-109 trees and in the rest – from 26 to 84 (7.4-25%) of the total number of trees, what lies within its coenotic optimum.

In four plantations the mazzard cherry was preserved, in one stand – one tree, in two other – 9-11 and in the next one – 20 trees. Linden was preserved in 14 plantations – from 1 to 44 trees, and in one stand there were 90 trees. Wild service tree survived in two plantations – one per every stand.

It was determined that composition of plantations significantly affects the stock of the stem wood, especially the yield of valuable assortments and their cost. Increasing the number of trees up to a certain limit of pedunculated oak, European ash and other valuable species in mixed stands, including natural seed plantation, placed in fresh oak forests, leads to the increase of the stock of stem wood, valuable assortments and their cost.

Keywords: *pedunculated oak, ecological potential, forest conservation and reforestation, principal and minor forest production cutting, climatic factors, high yielding plantations.*

Tabl. 2. Fig. 2. Lit. 8.

Problem statement. Oak in the forests of Ukraine is one of the most common and valuable species in many respects, and logging of its tree stands has always been a priority in economic activity.

Despite the economic stagnation and today's uncertainty of the basic principles of market management, the need for high-value oak assortments for economic and industrial purposes remains quite tangible and acute. Many years of experience show that traditional methods of management with a focus on clear felling and subsequent sprouting or creation of forest crops have failed to realize the idea of expanded reproduction of Ukraine's high-yielding and sustainable oak forests.

Repeated mass waves of drying delivered a tangible blow to the oak, as the main forest-forming species, forced to make certain adjustments in the economy, focusing primarily on carrying out sanitary felling. The latter have become a virtually decisive measure in the complex of economic activities in the oak forests. Intermediate cuttings (especially thinning) have automatically come to the fore, the main purpose of which is to prepare and form valuable oak specimens for the future. Still at the beginning of the century, a number of researchers noted that the germ character of oak forests and the lack of regular intermediate cuttings did not make it possible to form a high-value, both from the standpoint of productivity and fruiting, dominant coating in the complex multicomponent plantings, as a prerequisite for the lasting preparatory regeneration and, respectively, introduction of unconventional gradual and selection cuttings.

Analysis of the recent publications. The growing interest in oak forests, both in terms of raw materials and social factors, is a testament to the urgency of the problem. Even at the dawn of formation the principles of proper and indispensable management of the oak forests the works of G.M. Vysotskiy, G.A. Kornakovskiy, G.F. Morozov, A.A. Khytriy, A.P. Molchanov, O.M. Soboliev, B.I. Guzovskiy and others became well known to the general public. They were aimed at a deep study of the ecology of the oak forests and the search for rational ways of their management [1]. At the present stage of development of the forestry sector considerable attention is paid to the conservation and restoration of indigenous oak stands in the works of Bondar A.O., Krynytskiy G.T., Vasilevskiy O.G., Neiko I.S. and others [3-4].

Materials and methods of research. Laying of test areas was carried out on the plantations of forestry enterprises of Vinnytsia region, which have different composition, productivity and stock of SOU 02.02-37-476:2006 «Areas of trial forest management. Method of laying» [2]. The selected areas of indigenous and derivative stands of pedunculated oak were studied on the basis of forest taxation descriptions (as of 01.01.2012) and visually with the help of forest taxation instruments and reference materials. The data obtained were processed with the help of a Microsoft office software package and the program for determining the material and monetary value of the cutting area (MAG).

Results and Discussion. The predominant forest types of the Vinnytsia Regional Forestry and Hunting Association are fresh hornbeam and ash-hornbeam forests (88.5%). Among the most productive forest types dominate fresh (3.2%) and

dry (12%) forests. Wet hornbeams forests occupy a relatively small area (2.1%). Other types of forests are less represented. Most of oak stands that grow within the region, in terms of plantings composition, correspond to the types of forest plant conditions. Under those circumstances, most tree species show high growth rates. The area of plantations of the II class quality makes up 94.7%, 4.9% – of the III class quality and 0.4% – of the IV. The largest area (57.1%) is occupied by plantations with the density of 0.7, slightly smaller (31.8%) – with the density of 0.8, and plantations with the density of 0.9 to 1 occupy the area of 3.5%, with the density of 0.6 – 6.3%; 0.5 – 0.8%; 0.4 – 0.3% (Fig. 2) [3].

The highest rainfall – 516 mm per year and 386 mm per growing season – occurs on the territory of Mohyliv-Podilskiy State Forestry, the lowest (461 mm per year and 344 per growing season) – on the territory of Bershad and Tulchyn Forestries. According to this indicator, Illintsi and Vinnytsia Forestry Enterprises occupy an intermediate position. On their territory the precipitation level is 476 mm per year and 353 mm per growing season [7].

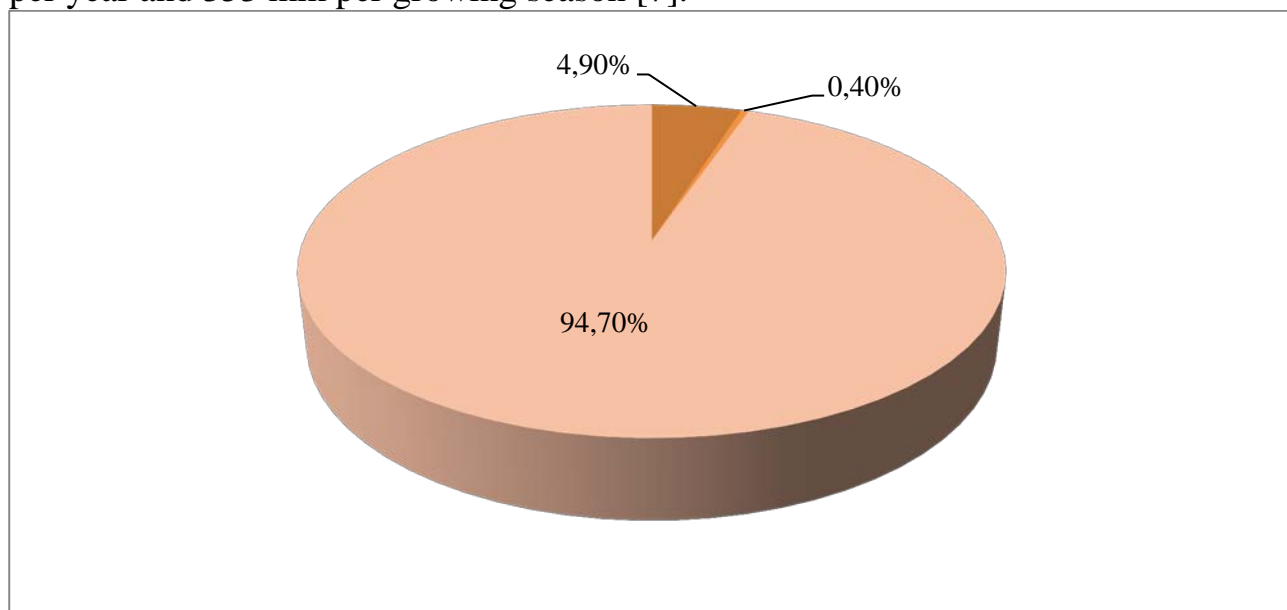


Fig. 1. Distribution of plantations of Vinnytsia Regional Forestry and Hunting Association according to the class quality as of 2017

Source: based on own research

According to the growing conditions, the largest part of the forestry area (97.5%) is occupied by the fresh woods in Tulchyn Forestry Enterprise. According to the reduction of the forest types, friendly to growing forest species, the forestry associations can be grouped in the following order: Illintsi (96% of the area is fresh oak forests), Mohyliv-Podilskiy (93.7%), Bershad (89.3%) and the last place is occupied by Vinnytsia Forestry Enterprise (77.5%) [3].

Under the same temperature conditions in all forestry and hunting enterprises, the most precipitation during the year and the growing season falls in Mohyliv-Podilskiy State Forestry.

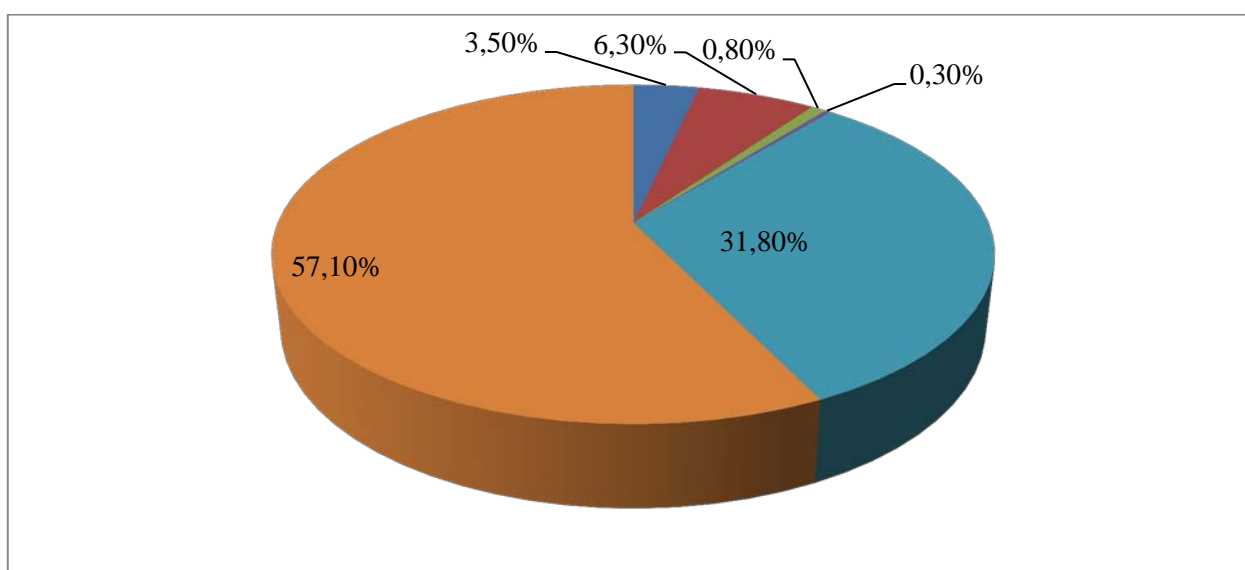


Fig. 2. Distribution of plantations of Vinnytsia Regional Forestry and Hunting Association according to density as of 2017

Source: based on own research

In this area the vegetation period lasts for the longest period of time and it has a quite large share of fresh oak forests. However, it has the smallest planting area with the density 0.8 (18.5%) and 0.9-1 (1.3%) and the largest with the density 0.5-0.6 (9 and 23.4% respectively). As of 01.01.2017 the enterprise has the largest (92.5%) area of plantations of class quality I and higher and the smallest area of plantations of class quality III (7%), IV (0.4%) and V (0.1%) [3]. As a result, the average stock of stands of all age groups and high-density stands in Mohyliv-Podilskiy State Forestry is the lowest.

As of 2017, the total area of plantations, which belongs to the oak high-stemmed economy is 21 4000 hectares, being the smallest (6898 hectares) on the territory of Vinnytsia Forestry Enterprise, the largest (25 422 hectares) on the territory of Mohyliv-Podilskiy State Forestry. The lowest average stock of stem-wood of all age groups of oak economy was in Mohyliv-Podilskiy, and the highest, with a few exceptions, in Illintsi.

Particularly high (460 m³ per hectare) average reserve of over-matured oak forests is located in Illintsi Forestry Enterprise. As of 2017, Vinnytsia Forestry has the lowest average increment of young (2.7 m³ per 1 ha), maturing (2.6 m³) and matured (2.4 m³) forests, and the highest (4.4 m³) of middle-aged plantations [3].

On the territory of the Regional Forestry and Hunting Association there are many plantations, which include introducers (Amur velvet, black walnut, white hickory, European larch, etc.). The productivity of plantations with their involvement is different and depends on many factors. It is well-known that the use of introducers is advisable when they have advantages over indigenous species: higher growth rate, more valuable wood or better technical characteristics, better fruits or berries, when they have a positive effect on the environment or may be used as decorative elements

in green building, etc. Therefore, the study of their forestry and economic properties will help to determine conditions and ways of their rational use in forest plantations.

Thus, the climatic and soil conditions of Vinnytsia region are favorable for the cultivation of plantations of pedunculated oak, but their productivity depends on economic measures, the most important of which are the technology of forest plantations creation, composition and scheme of mixing tree species on the area, location of seating places on the plots, especially in partial cultures, intensity and repetition of improvement cuttings. Reduction of density below justified level, from the forestry and economic points of view, as has been observed in Mohyliv-Podilskiy State Forestry, reduced the stock of oak stem wood of all age groups and the plantation as a whole (table 1).

Table 1

Area of oak high-stemmed plantations and average growth of stem wood in forestry and hunting enterprises of «Vinnytsia Regional Association of Forestry and Hunting» as of 2017

Group of plantations by age	Forestry and hunting enterprises					Total
	Vinnytsia SFHE	Bershad SF	Illintsi SF	Mohyliv-Podilskiy SF	Tulchyn SFHE	
Total area, ha	6898	10 725	17 296	25 422	23 295	214 000
Young forests, ha	514	1761	3462	3640	3868	39 499
Increase in timber, m ³	2,7	3,8	6,2	3,7	4,3	4,5
Middle-aged, ha	2895	4766	7048	10 761	11 588	99 316
Increase in timber, m ³	4,4	3,9	4,2	3,7	4,0	4,0
Maturing, ha	31	1685	673	2264	2249	17 800
Increase in timber, m ³	2,6	3,4	3,3	3,1	3,4	3,3
Matured and over-matured, ha	13	703	175	1035	863	8814
Increase in timber, m ³	2,4	3,1	2,9	2,7	3,2	3,0
Average age, years	60	57	53	62	60	60

Source: based on own research

It should be noted that even without attraction additional funds and labor force, in conditions of Vinnytsia region it is possible to form highly productive plantations with participation of pedunculated oak. This can be confirmed by the matured

artificial stands of Illintsi Forestry, whose average stock is 460 m³ per 1 ha, which is 2.12 times higher than the average for the total (215 m³ per 1 ha).

Despite the systematic intermediate cutting, which was carried out in order to preserve the pedunculated oak, European ash and other valuable species as a part of 92-132-year-old stands, the highest number of the preserved trees belongs to hornbeam (36.5-64.9% of the total number were in 19 plantations of Vinnytsia region). Only on two plantations 9.7-14.9% of hornbeam out of the total number of tree species was found.

In the distant past (92-132 years ago), logging was made manually. At that time, the assortments were transported by horse-drawn transport. Timber skidding was not carried out, and cutting wastes were burned. Logging sites were developed during the autumn and winter period, when labor force and horses were free from other works. When the logging is developed in winter, self-seeding and undergrowth are preserved better. Naturally, restoration in the fresh felling includes the undergrowth of hornbeam as well. The age of the latter is close to the undergrowth of pedunculated oak, European ash and linden. Therefore, the absence of undergrowth of hornbeam, which was the same age as the undergrowth of the main species, indicates that it was cut down during the intermediate felling. The age of the undergrowth of hornbeam that was preserved until the examination was 10-52 years less. However, in all plantations the hornbeam shows intensive growth, and in seven out of 21 plantations it is located in the first storey [8].

As was already mentioned above, during 92-132 years all measures were taken to preserve valuable tree species, including oak, ash, wild service tree, mazzard cherry, and small-leaf linden. However, very few of these trees have been preserved, what is too little for the survey. Only in five plantations there were 122 to 167 oak trees per ha. In the remaining 15 plantations 40 to 94 oak trees per ha were found.

According to biological and ecological properties, the optimum participation of European ash in plantation is 25-30% of the total number of trees provided they are evenly distributed over the area. According to our data, there were no ash trees in two stands, in one plantation only eight trees of ash were preserved, in the next three – 100-109 trees and in the rest – from 26 to 84 (7.4-25%) of the total number of trees, what lies within its coenotic optimum.

In four plantations mazzard cherry was preserved, in one stand – one tree, in two other – 9-11 and in one more – 20 trees. Linden was preserved in 14 plantations – from 1 to 44 trees, and in one stand – 90 trees. One specimen of wild service tree has survived in each of two plantations.

Thus, despite the fact that management measures were aimed at preserving major tree species in all natural plantations of seed origin, in Podillya forests the amount of the preserved self-seeding and undergrowth of European hornbeam was the greatest.

It is known that the composition of plantations significantly affects the stock of stem wood, especially the yield of valuable assortments and their cost. Increasing the number of trees up to a certain limit of pedunculated oak, European ash and other

valuable species in mixed stands, including natural seed plantation, placed in fresh oak forests, leads to the increase of the stock of stem wood, valuable assortments and their cost (table 2).

Table 2

Stock of stem wood and its cost in natural seed plantations in fresh oak forests of Vinnytsia region

Testing area	Composition	Species	Age, years	Average		Quality class	Density	Per 1 ha			
				height, m	diameter, cm			Number of trees,pc	stock, m ³	growth, m ³	cost, UAH
Bershad Forestry, quarter 28, section 1											
1	3oak3ash	Oak	122	27,5	41,9	I	0,37	64	115	-	3117
	2lind1hornb	Ash	100	28,2	38,1		0,32	62	80	-	935
	1maple	Cherry	60	24,3	28,3		-	1	1	-	6
	Ilstorey9hornb	Linden	100	25,4	31,1		0,14	45	37	-	65
	1maple	Hornbeam	90	22,5	24,5		-	272	159	-	152
		Norway maple	60	21,9	23,3		-	41	19,7	-	190
		Wild service tree	40	19,1	20		-	1	0,3	-	2
	Total						0,83	486	412	3,4	4467
Tomashpil Forestry, quarter9, section 1											
2	3oak3ash	Oak	98	30,7	46,1	I ^a	0,24	48	110	-	2195
	2lind2hornb	Ash	95	30,7	39,8		0,20	52	90	-	1524
		Hornbeam	80	25,9	26,3		0,20	120	88	-	946
		Norway maple	60	26,9	25,9		0,03	16	12	-	88
		Linden	80	27,8	33,7		0,12	48	54	-	147
	Birch	70	23,0	24,0	-		2	2	-	3	
	Total						0,79	286	356	3,6	4903
Bershad Forestry, quarter 13, section 9											
3	3oak5ash2lind	Oak	122	27,9	36,1	I	0,21	52	70	-	1994
	Ilstorey9hornb	Ash	124	28,6	47,3		0,42	60	145	-	2568
	1maple	Linden	110	26,2	37,6		0,20	44	56	-	145
		Norway maple	60	19,2	18,1		-	64	16	-	197
		Hornbeam	75	22,8	27,4		-	220	142	-	300
Total							0,79	286	356	3,6	4903

Source: based on own research

Thus, in the 122-year old plantation of Bershad Forestry, the total number of trees is 440, including 52 trees of pedunculated oak, 220 – of European hornbeam, the stock of stem wood is 429 m³ per hectare, the cost is 5204 UAH. Increase in the number of oak trees to 120 in the 112-year old plantation in the very Bershad forestry and decrease of hornbeam trees to 154 per 1 ha with a total number of trees about 422

pieces and the same stock of stem wood (427 m^3) per 1 ha, the cost of stem wood in plantation of the test area 6 increased to UAH 7933, or by 152%.

Even with a smaller total number of trees and the stock of stem wood of all species, but the larger number of oak trees, the cost of wood per unit of area significantly increases. In the 122-year old plantation of Bershad Forestry with 94 oak trees, the total number of all species of 352 and the stock of stem wood 410 m^3 per ha, the cost of the latter increased to 8180 UAH or 121%. Increase of the number of pedunculated oak trees in matured 92-132-year-old plantations of natural seed origin of Vinnytsia region from 48 to 164 trees per hectare increased the total stock of stem wood from 356 to 456 m^3 , or by 128%, and the total value – from 4467 to 11 004 UAH, or by 246%.

As already mentioned, the average age of high-stem oak plantations in Vinnytsia region is 57 years, the average stock of matured oak stands is 307 m^3 per 1 ha, and in low-stem 80-year old plantations the stock of stem wood is reduced to 208 m^3 per 1 ha. The stock of natural plantations of seed origin of the 92-132-year-old age in Vinnytsia region is $356\text{-}456 \text{ m}^3$ per 1 ha, what is higher than the average stock of 97-year-old matured high-stem oak stands by 115.9-148.5%.

Conclusions.

1. Natural conditions of Vinnytsia region allow growing high-yielding, stable oak plantations on large areas. However, the potential opportunities of forest plant conditions in the areas occupied by oak forests are not fully used (80% average). Therefore, one of the main tasks is to increase the productivity of oak forests by providing fuller use of growing conditions, creating optimal age structure and rational use of raw and non-raw forest resources.

2. The condition of oak plantations of the studied area in the last 10-20 years has been improved, the total amount of forested area has been increased, and the average stock of plantations of all age groups has been raised. The age structure of the oak plantation area is being optimized.

3. An analysis of the age structure of plantations in the area under study shows that they are predominantly of the same age, what is due mainly to clear felling.

4. In order to increase productivity and the stock of tree stands with predominance of pedunculated oak, it is advisable to pay more attention to the quality of felling, to supplement forest crops with introducer species, which are characterized by high biological stability and productivity.

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АНОТАЦІЯ **ОПТИМІЗАЦІЯ ВИРОЩУВАННЯ ДУБОВИХ ДЕРЕВОСТАНІВ В** **УМОВАХ ВІННИЧЧИНИ**

Основну частину лісових насаджень Вінниччини займають насадження з переважанням дуба звичайного (81%). Більшість дубових деревостанів, які зростають у межах Вінницької області, за складом насаджень відповідають типам лісорослинних умов. За таких обставин більшість деревних порід виявляє високу інтенсивність росту. За II бонітетом площа насаджень становить 94,7 %, за III – 4,9 % і IV бонітетом – 0,4 %. Найбільшу (57,1 %) площу займають також насадження повнотою 0,7, децю меншу (31,8 %) – з повнотою 0,8, а насадження з повнотою 0,9-1 розміщені на площі 3,5 %, з повнотою 0,6 – 6,3; 0,5 – 0,8; 0,4 – 0,3 %.

Незважаючи на систематичні рубки догляду, які проводилися з метою збереження дуба звичайного, ясена звичайного та інших цінних порід у складі 92-132-річних деревостанів, збереглося найбільше (в 19 насаджень Вінницької області було 36,5-64,9 % загальної їхньої кількості) дерев граба. Тільки у двох насадженнях виявлено 9,7-14,9 % граба від загальної кількості деревних порід. За біологічними та екологічними властивостями оптимальна участь ясена звичайного в складі насаджень становить 25-30 % дерев від їх загальної кількості за умови рівномірного розміщення по площі. Згідно проведених досліджень, у складі двох насаджень ясена не було, в одному збереглося тільки вісім дерев ясена, у трьох – 100-109 дерев і в решти – від 26 до 84 (7,4-25 %) загальної кількості дерев, що знаходяться у межах його ценотичного оптимуму. У чотирьох насадженнях збереглося лише кілька одиниць черешні звичайної, в одному насадженні – одне дерево, у двох – 9-11 і в одному збереглося 20 дерев. Кількість липи серцелистої в 14 насадженнях коливалася в межах від 1 до 44 дерев, а в одному насадженні близько 90 дерев.

Доведено, що таксаційні показники насадження суттєво впливають на запас ділової деревини. Із збільшенням дерев до науково обґрунтованої межі дуба звичайного, ясена звичайного та інших цінних деревних порід в насадженнях, в тому числі і в природних насінневих, що знаходяться у свіжих дібровах, збільшується запас стовбурової деревини, ділових сортиментів.

Ключові слова: дуб звичайний, екологічний потенціал, лісовідновлення та лісорозведення, рубки головного та побічного користування, кліматичні чинники, високопродуктивні насадження.

Табл. 2. Рис. 2. Літ. 8.

АННОТАЦИЯ

ОПТИМИЗАЦИЯ ВЫРАЩИВАНИЯ ДУБОВЫХ ДРЕВОСТОЕВ В УСЛОВИЯХ ВИННИЦЫ

Основную часть лесных насаждений Винницы занимают насаждения с преобладанием дуба обыкновенного (81%).

Большинство дубовых древостоев, которые растут в пределах Винницкой области, по составу насаждений соответствуют типам лесорастительных условий. При таких обстоятельствах большинство древесных пород проявляет высокую интенсивность роста. За II бонитетом площадь насаждений составляет 94,7 %, за третьим – 4,9 % и IV бонитетом – 0,4 %. Наибольшую (57,1 %) площадь занимают также насаждения полнотой 0,7, несколько меньшую (31,8 %) – с полнотой 0,8, а насаждения с полнотой 0,9-1 размещены на площади 3,5 %, с полнотой 0,6 – 6,3 %; 0,5 – 0,8 %; 0,4 – 0,3 %.

Несмотря на систематические рубки ухода, которые проводились с целью сохранения дуба обыкновенного, ясеня обыкновенного и других ценных пород в составе 92-132-летних древостоев, сохранилось всего (в 19 насаждений Винницкой области было 36,5-64,9% общего их количества) деревьев граба. Только в двух насаждениях обнаружено 9,7-14,9 % граба от общего количества древесных пород.

По биологическим и экологическим свойствам оптимальное участие ясеня обыкновенного в составе насаждений составляет 25-30 % деревьев от их общего количества при условии равномерного размещения по площади. Согласно проведенным исследованиям, в составе двух насаждений ясеня не было, в одном сохранилось только восемь деревьев ясеня, в трех – 100-109 деревьев и в остальных – от 26 до 84 (7,4-25%) общего количества деревьев, находящихся в пределах его ценотического оптимума.

В четырех насаждениях сохранилась черешня обычная, в одном – одно дерево, в двух – 9-11 и в одном 20 деревьев. Липа сохранилась в 14 насаждениях – от 1 до 44 деревьев, а в одном – 90 деревьев. Береки сохранилось по одному дереву в двух насаждениях.

Было установлено, что состав насаждений существенно влияет на запас стволовой древесины, особенно на выход ценных сортиментов и их стоимость. С увеличением количества деревьев до определенного предела дуба обыкновенного, ясеня обыкновенного и других ценных деревьев в смешанных насаждениях, в том числе и в естественных семенных, размещенных в свежих дубравах, повышаются запас стволовой древесины, ценных сортиментов и их стоимость.

Ключевые слова: дуб обычный, экологический потенциал, лесовосстановления и лесоразведения, рубки главного и побочного пользования, климатические факторы, высокопроизводительные насаждения.

Табл.2. Рис.2. Лит. 8.

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