A Agricultural sciences

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TO ESTABLISH THE CARBON-ABSORBING AND OXYGEN-FORMING CAPACITY OF OAK PLANTATIONS OF THE STATE ENTERPRISE «ZHYTOMYR FORESTRY» IN THE CONTEXT OF CLIMATE CHANGE

Over the past decades, climate change has led to a number of negative factors, including the extinction of certain plant and animal species, droughts, difficulties in growing crops, drying out and diseases of tree species[1], etc.

Taking into account these factors, the Paris Agreement was signed at the UN International Climate Negotiations (COP21) in 2015. Out of 197 countries that participated in the signing of the agreement, 176 ratified it. Ukraine was one of the first countries in the world to approve the agreement at the state level.

The main goal of the Paris Climate Agreement is to prevent the global average temperature from rising by more than 2°C (if possible, no more than 1.5°C) compared to the levels before the industrial revolution, when humanity began burning huge amounts of fossil fuels, which is the historical period up to the 1750s, when the industrial revolution began in England and later spread to Europe.

Keeping global warming at 1.5–2.0°C requires a rapid reduction in anthropogenic greenhouse gas emissions and their complete elimination by the second half of the 21st century[2].

To address local and global environmental issues, the Paris Agreement provides for the active use of emissions trading. A «quota» is a permit, a certificate for emissions of one ton of CO2 equivalent over a certain period of time, which can be transferred in accordance with the rules of the scheme. Greenhouse gas (GHG) emissions trading is a market-based instrument for reducing greenhouse gas emissions into

1 Golubets M.A. Ecosystemology. Lviv, 2000. 316 c.

2 Aleksiuk I.L. Peculiarities of changes in taxation indicators of pine stands of natural origin in Polissya of Ukraine depending on their composition. Scientific Bulletin: National University of Life and Environmental Sciences of Ukraine. Series: Forestry and ornamental gardening 187 (2) 2013. P. 9-15.

the atmosphere. The average cost of one greenhouse gas emission allowance is USD 18. Assuming the possibility of selling the difference between emissions and carbon storage, Ukraine would have a significant profit from the sale of allowances. In view of the above, the Ministry of Energy and Environmental Protection of Ukraine is considering ways to implement a greenhouse gas emissions trading system[3].

At the UN Climate Change Conference in Paris (2015), the positive role of forests in climate change was discussed. The importance of forests is based on the UN framework program approved in 2013 – REDD+ (Reducing Emissions from Deforestation and Forest Degradation).

In the process of their development, forest plantations form organic mass, performing a number of functions, including the accumulation of solar energy and the production of oxygen through photosynthesis. Every year, the biosphere's vegetation produces up to 55 billion tons of oxygen. In the forest environment, oxygen is released into the atmosphere mainly in the crown tier, where the bulk of green leaves are concentrated[4].

In the context of intensive industrialization and urbanization of the environment, which are characterized by excessive use of oxygen, there is a need to ensure a balance of oxygen consumption and production[5]. When burning fuels, humans cause irreversible losses of atmospheric oxygen (approximately 273 billion tons of O2 have been lost over the course of human existence)[6].

According to the Krakow researcher W. Staziecki, during the summer growing season, 1 m^2 of leaves produces the following amount of oxygen: lilac – 1.1 kg; aspen – 1.0; hornbeam – 0.9; ash – 0.89; oak – 0.85; pine – 0.81; maple – 0.62; hazel – 0.59; beech – 0.55; small-leaved linden – 0.47; acorn – 0.33 kg.

Thus, special attention should be paid to determining the carbon-absorbing and oxygen-producing capacity of tree plantations in order to improve sustainable forest management.

Ecological importance of forest plantations in the context of climate change. The forest ecosystems of Ukrainian Polissia perform crucial functions that ensure a stable state of the environment. Forest plantations accumulate and circulate substances, produce and store energy, regulate and protect the main physical characteristics of the environment in the face of external influences and, in

3 Matthews G. The Carbon Contents of Trees / G. Matthews // Forestry Commission, Tech. Paper 4. – Edinburgh, 1993. – 21 p.

4 Kaufmann M. R. The relationship of leaf area and foliage biomass to sapwood conducting area in four subalpine forest trees / M. R. Kaufmann, C. A. Troendle // Forest Sci. – 1981. – Y. 27. – № 3. – P. 477–482.

5 IPCC Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Firth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: IPCC,2015. 151 p.

6 IPCC Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Firth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: IPCC,2015. 151 p.

particular, climate change. Of particular importance is the function of forest phytocoenoses, such as the accumulation of organic matter and carbon storage[7].

The ecological functions of forests are the ability of forest plantations to provide the environment with protective, climate-regulating, water-protecting and water-regulating, soil-protecting, sanitary and hygienic (carbon accumulation, oxygen production) and recreational (health) capabilities[8]. Forest biogeocenoses affect the environment as a biological system, releasing matter and energy into the environment through photosynthesis, respiration, transpiration, etc. They reflect and absorb solar radiation, retain part of atmospheric precipitation, condense water vapor, retain dust, transfer surface runoff to intra-soil runoff, etc.

In general, among terrestrial ecosystems, forests are the main sink for carbon dioxide, which can naturally reduce its concentration in the atmosphere. The study of carbon stocks in pine plantations under different forest conditions is quite relevant. The data obtained from such studies make it possible to conduct a comparative analysis and determine which type of forest conditions plays the greatest role in carbon sequestration. Forests are recognized as the most reliable system for preventing the greenhouse effect in terms of the scale of production and, especially, the duration of carbon accumulation in woody plants[9].

The impact of forests on abiotic environmental factors is manifested in the following properties of forests: climate-improving (impact on wind and temperature conditions, solar radiation, oxygen release, carbon dioxide absorption, air ionization, etc.); water-protective (impact on air humidity, regulation of water catchment and drainage, improvement of water quality); protective (field protection, soil protection, noise protection, dust and gas protection). Assessment of the environment-forming role of forests, their protective properties, recreational and other loads is understood as environmental productivity[10].

The function of forest plantations to release oxygen and absorb carbon dioxide is considered a sanitary and hygienic phenomenon[11].

More than 60 % of oxygen is supplied by land vegetation, where forests are its main component. On warm, sunny days of summer, 1 hectare of forest,

7 Vasylyshyn R. D., Lakyda I. P., Shevchuk O. V., Lakyda M. O., Slyva O. A. Estimation of the energy intensity of live biomass components of pine stands in Ukrainian Polissya. Scientific Bulletin of the National University of Life and Environmental Sciences of Ukraine. Series: Forestry and ornamental gardening. 2015. Issue 229. C. 12-19.

8 Kadeba O. Above-ground biomass production and nutrientaccumulation in an age sequence of Pinus caribaea stands / O. Kadeba // Forest Ecol. and Manag. – 1991. – Y. 41, – № 3–4. – P. 237–248.

9 J. Canadell et al. Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity, and efficiency of natural sinks. Proceeding National Academy of Sciences of the USA. 2007. № 104. P. 18866–18870.

10 Moroz VV, Landin VP, Sahaidak AV, Rudenko OM, Zakharchuk VA, Solomko VL, Feshchenko VP Ecological functions of pine plantations of Chernihiv Polissya. Methodical recommendations. K., 2017. 49 p.

11 Krasnov V.P., Tkachuk V.I., Orlov O.O. Handbook of a forestry specialist. Reference edition. Zhytomyr – Novohrad-Volynskyi: NOVOGRAD Publishing House, 2013. 436 p.

absorbing 220–280 kg of carbon dioxide, releases 150–220 kg of oxygen, enough for 40–50 people to breathe. The formation of 1 ton of organic mass produces an average of 1.3–1.5 tons of oxygen.

The largest amount of oxygen is released by medieval plantations (from 30 to 60–80 years old). Pine plantations of the first class of bonitet with a fullness of 0.8 emit 10.9 tons of oxygen per year, birch – 10.8 tons per year, aspen – 9.7 tons per year[12].

Of all the carbon accumulated in vegetation, forest ecosystems account for the largest share (92 %). Plants in all other ecosystems accumulate only about 7 % of carbon, and oceanic plant organisms – less than 1 %. In general, the biological mass of green plants on the Earth's land is 2.4 × 1012 tons, or 99.2 % of the mass of all organisms. In the world's oceans, this percentage is much lower – 6.3 %. Forest biomass and soils contain about 50 % of the total carbon in terrestrial ecosystems, and forests currently absorb just over a quarter of total anthropogenic emissions, which is one of the most important ecosystem services in the context of climate change.

Deforestation and degradation of forest ecosystems is one of the most pressing environmental issues of our time. Reduction of forest area and decrease in their sustainability depend on excessive consumption of forest resources and the degree of environmental pollution and economic development of the state[13]. Therefore, in order to increase their productivity, it is necessary to carefully approach the issue of reforestation and reforestation.

As noted by V. P. Krasnov et al. forest ecosystems are the most complex plant communities on land. They are natural systems consisting of numerous interacting and interconnected components[14]. They are characterized by dynamic equilibrium, stability, self-regulation, which has developed as a result of long evolution and natural selection of all components of forest communities, as well as high regeneration capacity, a special balance of energy and matter, and geographical specificity. Their importance for stabilizing the ecological balance in the surrounding areas and on the globe in general is enormous. On the one hand, they largely owe their structure and existence to numerous abiotic factors, and on the other hand, they intensively influence them[15].

12 Scientific bases of diagnostics of anthropogenic damage to forest ecosystems. Forest Journal. 2011. №1. P. 24-28.

13 Bertash B.M. All about biomass. Scientific and popular edition. P.: Rivne Center for Marketing Research, 2011. 36 p.

14 Didukh Y. P. Ecological aspects of global climate change: causes, consequences, actions. Bulletin of the National Academy of Sciences of Ukraine, 2009. № 2. C. 34-44.Golubets M.A. Ecosystemology. Lviv, 2000. 316 p.

15 Carbon, climate and land management in Ukraine: the forest sector: [monograph]. Korsun-Shevchenkivskyi, FOP V. M. Havrylenko, 2014. 283 p.

Forest plantations have environment-forming functions, which are expressed in cost savings by reducing damage from adverse natural phenomena (droughts, windstorms, soil deflation and erosion) and air pollution[16]. The efficiency assessment also takes into account the social role of forest plantations, such as sanitary and recreational. The sanitary role of forest plantations is reflected in the localization of: harmful substances from industrial emissions; prevention of heavy metal pollution from motor vehicle emissions[17].

Forests perform health-improving functions. It cleans the air of dust and gaseous toxicants, enriches the air environment with oxygen and negatively charged ions, has antimicrobial and sterilizing properties, and affects the carbon cycle in nature, in particular, assimilates and retains its compounds for a long time.

In his publications, G. M. Vysotsky pointed out the positive spatial impact of forest plantations on the environment[18].

Forest plantations are effective carbon storage (reserves) that can naturally reduce its concentration in the atmosphere and bind it in the wood and bark of tree trunks and branches for a long time.

The carbon cycle begins with the fixation of atmospheric carbon dioxide in the process of photosynthesis (in plants and some microorganisms). Some of the carbohydrates formed are used by the plant itself to produce energy. At the same time, carbon dioxide (a reaction product) moves through the leaves or roots of the plant. Part of the carbon fixed by plants is consumed by animals with food and released as carbon dioxide in their respiration. Dead plants and animals are decomposed by soil microorganisms, and the carbon in their tissues is oxidized to dioxide and returned to the atmosphere.

Carbon is a component of all organic matter, which is why its cycle is the most widespread in nature[19]. It is carried out through the trophic chain of three groups of organisms: producers (phytoplankton) that capture carbon as part of carbon dioxide during photosynthesis; consumers (zooplankton, fish) that absorb carbon as part of organic matter that makes up the bodies of lower-order producers and consumers; and reducers (microorganisms) that return carbon to the cycle[20]. The carbon dioxide turnover rate is about 300 years.

16 Neretin S. D., Chiglyaev IF, Zaremsky AD Instruction on the organization of the forest fund of Ukraine. Field work. PA «Ukrderzhlisproekt». Irpin, 2006. 75 p.

17 Krasnov V.P. Phytoecology with the basics of forestry. Study guide for universities. Sumy, 2012. 415 p.

18 Kashpor S.M. Forestry reference book. K.: Vinnichenko Publishing House, 2013. 496 p.

19 Inventory of greenhouse gases in the sector of land use and forestry: [monograph]. KH.: KHNAU, 2008. 232 p.

20 Methodological aspects of estimation of annual carbon flow in forest plantations. Scientific Bulletin of the National Academy of Sciences of Ukraine. K., 1998. Issue 8. P. 221-227.

In the process of their development, forest plantations form organic mass, performing a number of functions, including the accumulation of solar energy and the production of oxygen through photosynthesis[21]. Every year, the biosphere's vegetation produces up to 55 billion tons of oxygen.

In the forest environment, oxygen is released into the atmosphere mainly in the crown tier, where the bulk of green leaves are concentrated.

Climate is one of the most important issues of our time in the world and in Ukraine. Many scientists from different countries, as well as domestic scientists, are concerned with the study of this issue, the problems of the present and the consequences for our future generations.

Prominent meteorologists I. Buchynskyi and K. Logvinov were the first to draw attention to the problem of climate change in Ukraine. The latter was the first researcher to put forward a scientific hypothesis that the climate of Ukraine is influenced not only by natural but also by anthropogenic factors on a global and regional scale, and to outline methodological approaches to climate change forecasting. His research showed the presence of periodicity in precipitation series.

The main forest-forming factors in Polissia are climatology and hygrotop. In addition, certain climate changes are currently taking place in the world, and the anthropogenic load to which the Polissia region has been subjected over the past hundred years is definitely affecting climate change in the region. Excessive logging, illegal amber mining, violation of the hydromelioration regime, and climate change have a negative impact on forest ecosystems, including the economically valuable scots pine[22].

MATERIALS AND RESEARCH METHODS

In planning the experiment, the methodology of scientific research was used, which is based on the collection of the studied material, its statistical processing using arithmetic averages, and methods of analysis, synthesis, and mathematical modeling.

The implementation of the research program included the following planned stages of work: studying literature and information materials about the research object; analyzing programs and methods for research; collecting empirical material; processing the results; summarizing the work in accordance with the collected research material[23].

21 Parametric structure of pine forests of the eastern Polissya of Ukraine. Scientific works of the Forestry Academy of Sciences of Ukraine: a collection of scientific papers. Lviv: RVV NLTU of Ukraine. 2013. Issue 11. P. 139-143.

22 Ibid.

23 Ukraine. Ecological and geographical atlas. Atlas-monograph. K.: Varta, 2006. 220 p.

Preparatory work involves studying the research object, processing the necessary primary information materials, and analyzing the existing experience in solving similar problems. Desk-based processing of the collected empirical data required systematization, taxonomic calculation, mathematical modeling of biometric indicators, modeling of dependencies between taxonomic values and indicators of phytomass of trees in the plantation.

The analysis of indicators was carried out based on the materials provided by the taxation descriptions of the State Enterprise «Zhytomyr Forestry» in the forestries – Bohunske, Berezivske, Korabelne, Levkivske, Novozavodske, Stanyshivske, Tryhirske, Pylypivske).

The collection of research material was carried out according to a methodology that involves further calculations using the Microsoft Excel analysis package; for mathematical modeling and statistical data processing, the methods of A. I. Kobzar, A. I. Gerasimovich, Y. I. Matveev, V. A. Greshnikov, and others were used.

The following forestry and taxation methods were used: induction and deduction; method of mathematical statistics; method of mass observations.

The inductive method, from the individual to the general, contained formulas and laws that characterized the dynamics of inventory values. The element of deduction was present in the form of accumulated literary and scientific knowledge about similar objects.

The mathematical and statistical method was used to determine taxation indicators, patterns of plantation structure, and to identify taxation errors. The arithmetic mean was used to characterize certain populations. The methods of variation statistics, which include the theory of probability and the theory of correlation, were used. The basis of the methods in variational statistics is the law of normal distribution.

The method of mass observations consisted of analyzing, classifying, and drawing appropriate conclusions from the collected material and developing taxation standards for the conditions of observation.

The average diameter (cm) and height (m) were determined on the basis of taxonomic descriptions.

Completeness was defined as the ratio of the sum of the cross-sectional areas of the trees of the stand $m^2 \times ha^{-1}$ to the sum of the cross-sectional areas of the complete stand (normal stand with completeness $m^2 \times ha^{-1}$).

The research of phytomass stocks in forest stands is based on the methodology of P. I. Lakida. This methodology is widely used in Ukraine, combining research on the biological productivity of forest plantations with taxonomic and biometric methods. The basis of such experimental studies are the taxation developments of K. E. Nikitin, A. A. Strochynskyi, A. Z. Shvydenko and others.

The analysis of the obtained research results is supplemented by the developments of scientists from different countries who have worked and continue to work on this problem, namely: (O. A. Usoltsev, A. I. Utkin, P. I. Lakida, etc.).

The phytomass of forest plantations is used to determine the course of processes in forest ecosystems, and is used for environmental monitoring of sustainable forestry, modeling the productivity of forest plantations and assessing their carbon sequestration capacity.

Statistical analysis of the experimental material and mathematical modeling were performed using modern computer programs AtteStat, Microsoft Excel, using the methods of A. I. Gerasimovich, A. I. Kobzar, Y. I. Matveev, P. I. Lakida, etc.

The biomass productivity of stands is a complex, urgent problem that is the subject of various scientific disciplines: ecology, forestry, forest taxation, and ecological tree science. This is due to the incompleteness of the study of forest biogeocenoses in terms of a joint investigation of their structure and functioning. Most research focuses on the study of forest biomass in two areas: biogeocenological (ecological) and resource studies.

Ecological research is carried out according to the methods of the International Biological Program (IBP) of 1964–1974 and their modifications; these are studies related to the study of the patterns of accumulation, cycle of substances and energy in phytocoenosis; they include an assessment of the reserves of atmospheric carbon bound in woody products. In Ukraine, scientific research was conducted by V. K. Myakushko (1972), Y. P. Odynak, D. V. Borsuk (1977), A. P. Andrushchenko (1978), Y. P. Odynak (1983), P. I. Lakida (2001), M. M. Petrenko (2002), A. M. Bilous (2009), and others.

The study uses an integrated approach that combines stereometric and regression methods with the use of conversion factors and its combination with forestry information banks. A similar method is used in their research by P. I. Lakida, V. A. Usoltsev, D. B. Botkin, L. G. Simpson, H. A. I. Madgwick, T. Satto.

The volume of tree trunks was calculated according to the basic formula of forest taxation (1):

$$V = g \times h \times f, \quad (1)$$

where V – volume of the trunk, m3;

g – cross-sectional area of the trunk at a height of 1.3 m, m2;

h – height of the tree trunk, m;

f – old species number.

The cross-sectional area of the trunk is determined by the formula (2):

$$g = \frac{\pi \times d^2}{40000} \quad (2)$$

where π – number 3.14;

d – diameter at a height of 1.3 m;

h – height of the tree trunk.

The coefficient of full-trunkedness of the trunk f was determined by the formula proposed for trees by V.A. Svinchuk, S.M. Kashpor, V.V. Myroniuk (2014).

The formula is as follows (3):

$$f = 0{,}381 \times 0{,}495 \times d^{-0{,}481}, \quad (3)$$

The percentage of bark volume was determined according to the standard tables of A.Z. Shvidenko, A.A. Strochinsky, Y.N. Savich, S.N. Kashpor (1987).

The phytomass of wood and bark in a completely dry state was determined by the formula:

$$m = V \times p_{bas}, \quad (4)$$

where p_{bas} – basic density of the phytomass fraction, kg·m^3;

m – mass of the phytomass fraction sample in an absolutely dry state, kg;

V – volume of the sample trunk depending on the diameter and height, m^3.

Basic density of phytomass fractions (p_{bas}) was used according to published data by P.I. Lakida (2002) for massive oak forest stands with a wood density of 602 and bark density of 436.

To establish the phytomass of the crown of Scots pine, we used the «Standards for estimating the components of aboveground phytomass of stands of the main forest-forming species of Ukraine» edited by P.I. Lakida (2013).

The obtained data were approximated by the empirical equation of multiple statistical allometry, which describes the dependence of tree phytomass components on its morphometric parameters (height, diameter):

$$y = a_0 \cdot x_1^{a_1} \cdot x_2^{a_2} \ldots x_n^{a_n}, \quad (5)$$

where a_0, a_1, a_2 – constants, known in econometrics as the derivative of the Cobb-Douglas function;

x_1, x_2, x_n – morphometric parameters of the tree, in our case x_1 – diameter, cm; x_2 – height, m.

The total phytomass of the tree was determined by the equation:

$$M_{fr} = m_{der} + m_k + m_{kr} \qquad (5)$$

where M_{fr} – total phytomass of tree fractions, kg;

m_{der} – wood phytomass, kg;

m_k – bark fluoromass, kg;

m_{kr} – crown phytomass, kg.

The phytomass of the stand (t×ha^{-1}) was defined as the phytomass of all trees in the stand per unit area.

Conversion coefficients were determined by the equation of F. Flury:

$$R_V = \frac{M_f}{M} = a \times A^b, \qquad (6)$$

where R_V – conversion factor, t×m$^{3;}$

M_{fr} – phytomass of a certain stand fraction, t×ha$^{-1;}$

M – stock of wood in the bark, m^3×ha^{-1};

a, b – constant regression coefficients;

A – plantation age, years.

According to P.I. Lakida, conversion factors allow to determine the total aboveground phytomass and estimate the carbon stock both for an individual tree and for the whole region in a reliable and timely manner.

The main methodological approaches to determining the carbon-absorbing and oxygen-producing capacity of pine plantations. The determination of the carbon stock of Scots pine, under fresh harvest conditions, was to study the amount of carbon present in the forest ecosystem at any given time. It is measured in tons of carbon and its derived units.

The share of carbon in phytomass in absolutely dry, according to the IPCC methodology (Intergovernmental Panel on Climate Change, 2015), is 50 % of the phytomass of fractions in absolutely dry condition. G. Matthews (1993) proposed to use a share of 45 % for needles and leaves.

The assessment of oxygen productivity in forest plantations was carried out according to the method of I. Liepa, who, based on the equation of photosynthesis, developed a method for determining the oxygen-producing capacity of the woody layer of the forest phytocoenosis. According to the developed methodology, the quantitative and chemical composition of woody phytomass in a completely dry state determines the amount of oxygen produced by forest plantations over a certain period of time.

This methodology does not take into account the needles, since the oxygen released during its formation is completely lost to decomposition after precipitation. According to the methodology of I. Liepa, the oxygen content in the process of accumulation of one ton of absolutely dry matter of different types of tree species reaches 1.4 tons, so the oxygen productivity coefficient is taken as 1.4.

RESULTS AND THEIR DISCUSSION

The State Enterprise «Zhytomyr Forestry» (hereinafter referred to as SE «Zhytomyr Forestry») conducts forestry operations on the area of 41.2 thousand hectares. The area covered by forest vegetation is 37.1 thousand hectares. The species composition is dominated by conifers (41.2 %), hardwoods (41.6 %) and other species (17.2 %). The company conducts balanced forestry, the average size of forest use per 1 ha of forested land is 3.9 m^3, and the average growth per 1 ha of forest land is 4.4 m^3.

The Zhytomyr Forestry State Enterprise includes eight forestries: Bohunske, Berezivske, Korabelne, Levkivske, Novozavodske Pylypivske, Stanyshivske, and Tryhirske. In addition, the forestry also includes a basic forest nursery, a timber processing complex, a motor transport shop, and a timber warehouse at Zhytomyr station.

The state-owned enterprise is located in Zhytomyr Polissya, a moderately continental climate with humid summers and mild winters. The average temperature in January is -5.7° and in July +18.9°. The absolute minimum is -35, -40°, the absolute maximum is +35, +40°. The period with temperatures above +10° is 158 days. The sum of active temperatures is 2390–2520°. Precipitation in the north is 600 mm, in the south – 570 mm per year, most of it falls in summer. The snow cover is 20–30 cm high.

3 unfavorable climatic phenomena are rainless periods of up to 60 days, possible droughts and dry winds, heavy rains, 1–2 days (less often 4–6 days) with hail. Late spring and early fall frosts cause significant damage. In winter, low temperatures are possible for 25 days, and ice for up to 15 days or more.

According to the analysis, it was found that the majority of oak stands of the State Enterprise «Zhytomyr Forestry», according to the types of forest vegetation conditions (FVC), grows in conditions of fresh soil (D2), wet soil (D3), fresh subsoil (C2), and wet subsoil (C3).

For further analysis, we divided the forest plots into types of forest vegetation conditions. The results are presented in Appendix A.

The development of oak plantations in the State Enterprise «Zhytomyr Forestry» was determined by biometric indicators (Figs. 1–2).

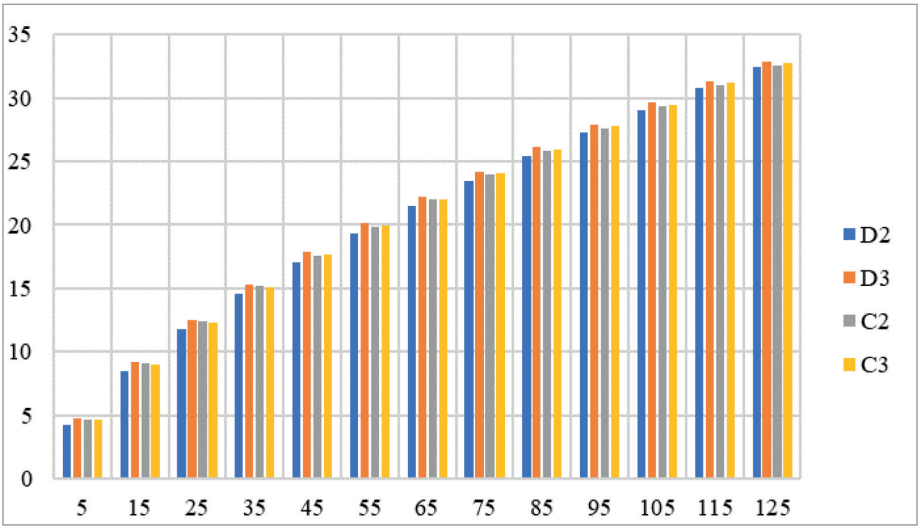

Fig. 1. Changes in the average diameter of oak stands depending on age

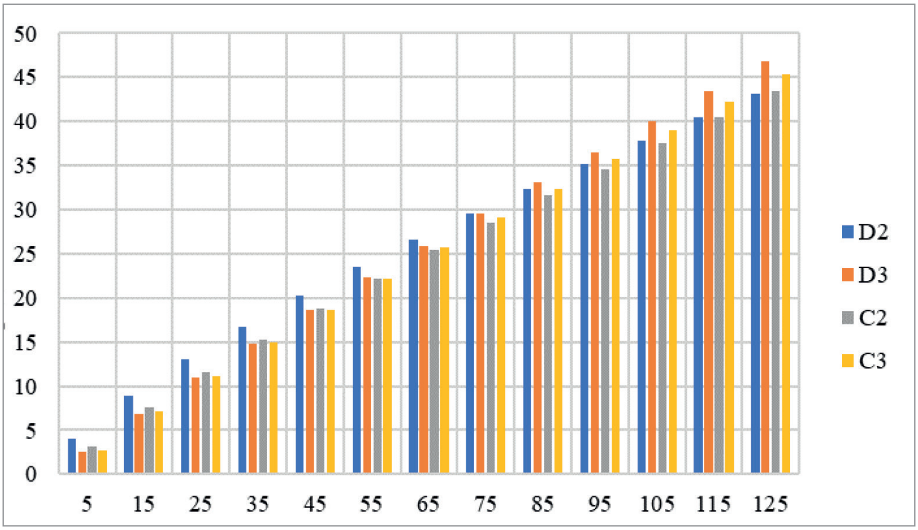

Fig. 2. Changes in the average height of oak plantations depending on age

Thus, oak plantations develop best under D3 conditions, which is fully confirmed by the literature.

The calculations were performed using formulas 1–5, and the results of the analysis are presented in Appendix C.

To establish correlations between taxonomic indicators and phytomass of different tree fractions, we used the Microsoft Excel data analysis package and constructed correlation matrices by type of site conditions of pine plantations (Tables 1–4).

Table 1

Correlation matrix of pairwise coefficients of oak plantations under conditions of D2

Indicators	Age, years	Average height, m	Average diameter, cm	Average wood phytomass, kg	Average bark phytomass, kg	Average crown phytomass, kg
Age, years	1,00	–	–	–	–	–
Average height, m	0,863	1,00	–	–	–	–
Average diameter, cm	0,929	0,935	1,00	–	–	–
Average wood phytomass, kg	0,967	0,918	0,991	1,00	–	–
Average bark phytomass, kg	0,970	0,914	0,989	0,999	1,00	–
Average crown phytomass, kg	0,968	0,917	0,991	0,999	0,999	1,00

According to the data obtained, it can be concluded that in D2 languages there is a fairly high correlation (0.863 – 0.999) between all indicators.

Table 2

Correlation matrix of pairwise coefficients of pine plantations under D3 conditions

Indicators	Age, years	Average height, m	Average diameter, cm	Average wood phytomass, kg	Average bark phytomass, kg	Average crown phytomass, kg
Age, years	1,00	–	–	–	–	–
Average height, m	0,901	1,00	–	–	–	–
Average diameter, cm	0,852	0,912	1,00	–	–	–
Average wood phytomass, kg	0,860	0,909	0,993	1,00	–	–
Average bark phytomass, kg	0,859	0,905	0,992	0,999	1,00	–
Average crown phytomass, kg	0,860	0,909	0,993	0,999	0,999	1,00

According to the correlation matrix (Table 2), under D3 conditions, the relationship between height and tree phytomass components is above average, while the relationship is quite high for the other indicators.

Table 3

Correlation matrix of pairwise coefficients of oak plantations under C2 conditions

Indicators	Age, years	Average height, m	Average diameter, cm	Average wood phytomass, kg	Average bark phytomass, kg	Average crown phytomass, kg
Age, years	1,00	–	–	–	–	–
Average height, m	0,955	1,00	–	–	–	–
Average diameter, cm	0,889	0,860	1,00	–	–	–
Average wood phytomass, kg	0,883	0,855	0,987	1,00	–	–
Average bark phytomass, kg	0,888	0,861	0,986	0,999	1,00	–
Average crown phytomass, kg	0,884	0,856	0,987	0,999	0,999	1,00

Under conditions of fresh and moist soil, there is a close correlation between all indicators (Tables 3, 4).

Table 4

Correlation matrix of pairwise coefficients of pine plantations under C3 conditions

Indicators	Age, years	Average height, m	Average diameter, cm	Average wood phytomass, kg	Average bark phytomass, kg	Average crown phytomass, kg
Age, years	1,00	–	–	–	–	–
Average height, m	0,837	1,00	–	–	–	–
Average diameter, cm	0,914	0,860	1,00	–	–	–
Average wood phytomass, kg	0,933	0,787	0,980	1,00	–	–
Average bark phytomass, kg	0,937	0,766	0,943	0,965	1,00	–
Average crown phytomass, kg	0,937	0,787	0,979	0,999	0,973	1,00

The obtained high correlation coefficients allow us to establish the indicators of regression statistics and analysis of variance, and to obtain the power dependence of the impact according to Equation 3, depending on the type of forest vegetation conditions.

To obtain a power law relationship between the diameter, height, and total phytomass of a tree, we logarithmize these indicators and use the Microsoft Excel data analysis package to perform regression and analysis of variance.

At the age of 80 years in the State Enterprise «Zhytomyr Forestry», oak plantations in forest vegetation conditions D3 accumulate the largest phytomass (170.3 t/ha) and, therefore, their carbon-absorbing and oxygen-producing role is higher and amounts to 106.4 t/ha and 276.3 t/ha, respectively.

According to the published data of Ivanyuk I.D., Ivanyuk T.M., Savushchyk M.P., Popkova M.Yu. Kvasna oak plantations in Zhytomyr Polissya grow in a fresh bore – 2.9 ha, fresh subbore – 1629.5 ha, wet subbore 4477.4 ha, wet subbore – 92.1 ha, wet subbore – 0,4 hectares, fresh subsoil – 29356.2 hectares, wet subsoil – 55805.7 hectares, raw subsoil – 743.0 hectares, wet subsoil – 4.1 hectares, fresh subsoil – 14059.3 hectares, wet subsoil – 9122.9 hectares, and raw subsoil – 23.6 hectares.

Taking into account the published data, we have established the distribution of phytomass, carbon and oxygen in the common oak in different types of forest vegetation conditions in the Zhytomyr Polissya.

So, despite the fact that common oak, as a single tree species, absorbs carbon and produces oxygen the most under D3 conditions, in Zhytomyr Polissya under C3 conditions its area is the largest, and therefore the amount of carbon absorption is higher and amounts to 5.6 million tons, and oxygen production is 14.6 million tons.

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