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BIOLOGICAL FEATURES OF THE STRUCTURE AND FUNCTIONS OF FIELD PROTECTIVE FOREST BELTS OF THE RIGHT-BANK FOREST-STEPPE

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In modern conditions, the current problem of agrosphere is its stability and constant improvement of the functioning of ecosystems. Therefore, the issue of creating and restoring a system of field protective forest plantations is one of the most radical directions of maintaining the stability of ecosystems, increasing their buffering capacity by restoring forest biocenoses, which are an integral part of natural landscapes. The goal is to assess the species diversity of field protective forest belts, compare the phytocenotic structure of the diversity of stands, and determine the main signs of the formation of forest biocenosis in shelterbelts as confirmation of their biological stability. The research was conducted on the base of scientific materials of well-known scientists on the biological aspects of the functioning of forest shelterbelts in the conditions of climate change. The main features of field protective forest belts, their species composition and vertical arrangement in the structure of the biogeocenosis are also characterized. The significance of each component of the trophic food chain, which ensures the circulation of substances and energy, is considered. It is such processes that ensure the development of the forest biocenosis and are stable self-regulating systems. Shelterbelts form a stable vegetation cover. Climatic conditions, are climatic factors, that directly affect the environment and are a habitat for animal and plant organisms, fungi, viruses and bacteria. The diversity of the species in shelterbelts is, accordingly, related to the life span of plant groups. Forest shelterbelts are biocenoses that provide an increase in the species of plant and animal organisms. The current task is not only the care for the existing forest shelterbelts, but also the planting of the new ones. Therefore, the younger are the shelterbelts, the more diverse and intensive is life in them.

Key words: *phytocenosis, living above-ground cover, species diversity, biogeocenosis, biodiversity, stratification, stability, forest biocenosis, coenotic structure.*

Вітер Н.Г. Біологічні особливості будови та функцій полезахисних лісосмуг Лісостепу Правобережного

В сучасних умовах актуальною проблемою агросфери є її стабільність та постійне підвищення функціонування екосистем. Тому питання створення та відновлення системи полезахисних лісових насаджень, являється одним найбільш радикальних напрямків підтримання стійкості екосистем, зростання їх буферності за рахунок відновлення лісових біоценозів, які являються складовою частиною природних ландшафтів. Мета – надати оцінку видовому різноманіттю полезахисних лісосмуг, провести порівняння фітоценотичної структури різноманітності насаджень, а також визначити основні ознаки формування лісового біоценозу в полезахисних лісосмугах як підтвердження їх біологічної стійкості. Дослідження проводились через опрацювання наукових матеріалів відомих науковців щодо біологічних аспектів функціонування полезахисних лісосмуг в умовах зміни клімату. Також охарактеризовані основні ознаки полезахисних лісосмуг, їх видовий склад і вертикальне розташування у структурі біогеоценозу. Розглядається значення кожного компонента трофічного ланцюга живлення, що забезпечують кругообіг речовин та енергії. Саме такі процеси забезпечують розвиток лісового біоценозу і є стійкими саморегулюючими системами. Полезахисні лісосмуги формують стійкий рослинний *покрив. Кліматичні умови, являються кліматичними факторами, які безпосередньо впливають на навколишнє середовище та є місцем існування тваринних і рослинних організмів, грибів, вірусів та бактерій. Різноманітність видів полезахисних лісосмуг відповідно пов'язана з тривалістю життя рослинних угруппувань. Полезахисні лісосмуги є біоценозами які забезпечують збільшення видів рослинних та тваринних організмів. Актуальним завданням сьогодення являється не тільки догляд за існуючими полезахисними лісосмугами, а висаджування нових. Тому, чим молодші полезахисні лісосмуги, тим різноманітніше та інтенсивніше в них життя.*

Ключові слова: *фітоценоз, живий надґрунтовий покрив, видове різноманіття, біогеоценоз, біорізноманіття, ярусність, стійкість, лісовий біоценоз, ценотична структура.*

Relevance of the research topic. The growing interest in determining the ecological functions of forest shelterbelts is associated not only with the deterioration of their condition in Ukraine over the past 15-20 years, but also with the problem of biodiversity loss. By studying the biological aspects of the functioning of forest shelterbelts as a forest biogeocenosis, it is possible to establish signs of its stability. We have studied the vertical structure of the phytocenosis of forest shelterbelts – woody, understory, herbaceous and underground layers and determined the changes in the conditions of the existence of the number of biota in conditions of climate change. Forest shelterbelts play an important role in conducting agricultural activities. They have the following functions, such as protecting crops and pastures from dry winds, protecting farm animals from winds. Shelterbelts are a habitat for wild animals and birds, they prevent salinization and soil erosion, contribute to moisture conservation and are barriers to the spread of weeds and pests. Forest shelterbelts affect the increase in productivity on agricultural lands adjacent to them.[1].

Petrovych O.Z. states that: "Field shelterbelts are an important part of the agricultural landscape. They play a significant role in the functioning and development of agroecosystems, slowing down wind speed, retaining snow on the fields, reducing surface runoff of atmospheric precipitation, increasing soil moisture, preventing wind erosion of the soil, and also increasing and stabilizing crop yields. The method of land reclamation is a factor in restoring the ecological and biological balance of agricultural lands. Field shelterbelts contribute to the formation of floristic and faunal diversity, the creation of new topical connections, the balancing of new biogeocenoses and thus serve as an effective means of forming of the biological fullness of agricultural lands" [2]. Having proven the importance of the above ecosystem functions and services of forest shelterbelts, they must be taken into account when studying and adopting relevant regulatory acts and developing new ones. Forest shelterbelts form floristic, faunal diversity and new topical connections, ensure the balancing of new biogeocenoses and are a reliable way to form biologically complete agricultural lands" [3].

Statement of the problem. The aim of the article is to assess the species composition of field shelterbelts, conduct a comparative analysis of the phytocenotic structure of the diversity of stands and determine the main features of the formation of forest biocenosis. Also, the task is the analysis of the biological features of the functioning of field shelterbelts of the Right-Bank Forest-Steppe under the conditions of intensification of agriculture and climate change.

The ideas of biocenology are set out in the works of V.V. Dokuchaev (1892), in which he had proved the need to study all natural factors (soil, climate, moisture, organisms), which are comprehensive and mutually dependent. Biocenology and the study of phytocenosis are the basis of one of the directions of the science of forest types – biogeophytocenotic, the founder of which is V.M. Sukachev. His biogeocenotic approach considered the type of forest belts from the position of a systemic approach – the unity of the forest (biocenosis – the totality of phytocenosis and zoocenosis) and the environment (ecotype) [4].

Artificial phytocenoses are cultural phytocenoses, forest shelterbelts are stripocenoses, and the process of creating phytocenose cultures is cultural anthropogenic successions. V.M. Sukachev in his scientific research had proved the need to study agrophytocenoses. Famous scientists M.M. Romanenko and A.V. Romanenko claim that forest shelterbelts are forest plantations artificially created to protect agricultural lands from drought and soil erosion. V.Yu. Yukhnovskyi, V.M. Malyuga, M.O. Shtofel, S.M. Dudarets note that forest shelterbelts are one of the main ways of biologizing agriculture, because they protect agricultural lands from adverse natural phenomena (dry spells, droughts, blizzards, water and wind erosion) and perform a multifunctional role in improving the environment. Forest shelterbelts are artificial plantations that delimit arable land massifs, performing climate-regulating, soil-protective and water-protective functions" [5, 6].

The scientific works of the following scientists in the field of agriculture are devoted to the problematic issues of highly effective functioning of field shelterbelts: V.O. Bodrov, G.B. Gladun, S.M. Dudarets, V.I. Koptev, V.V. Lukish, V.M. Malyuga, O.I. Pylypenko, A.P. Stadnyk, M.O. Shtofel, V.Yu. Yukhnovskyi. Forest ameliorator-topologist professor V.D. Vorobyov highly appreciated the importance of typology for field protective afforestation work, since it opens up the possibility of differentiating silvicultural techniques in accordance with the forest and vegetation conditions of the Forest-Steppe [7]. The prolongation of the main types of natural forests for steppes according to Alekseev's typological grid, practiced by G.M. Vysotskyi, is an example of the use of the method of comparative ecology. The success of the growth of artificial forest-steppe plantations is determined by the successful selection of the tree and shrub species, which can be facilitated by forest typology [8].

Research methodology. The methodological task in studying ecosystems (biogeocenoses) of forest shelterbelts is a systemic approach, because all the parts in the hierarchical structure of ecological systems, uniting, give them new features and qualities, since the system is characterized by emergence. Having considered the biological aspects of the functioning of forest shelterbelts, we identified signs of forest biogeocenosis in them. We analyzed the vertical structure of the phytocenosis of forest shelterbelts (tree, understory, herbaceous and underground layers) based on the study of literary sources on the topic of the research. The practice of forest shelterbelt afforestation is associated with such names as N.K. Genko, V.P. Skarzhinskyi, A.A. De-Carrier, V.M. Karamzin, M.K. Sredinskyi, G.M. Vysotskyi. Theoretical foundations, accumulated analytical and practical experience are found in the works of G.V. Vysotskyi, V.O. Bodrov, B.Y. Logginov, Y.P. Byalovich, V.I. Koptev, M.M. Miloserdov, M.Y. Dolgilev, O.I. Pylypenko, A.P. Stadnik, G.B. Gladun, V.Yu. Yukhnovskyi and the other researchers. Familiarization with their works allows us to reflect the modern scientific picture of the biological functions of field shelterbelts [9].

The ecosystem of forest shelterbelts contains all the components of the trophic chain – producers, consumers and decomposers, which ensure the circulation of substances, energy and the development of forest biocenosis. As producers, forest shelterbelts are the first link in the complex of trophic chains, a center for biodiversity conservation and can play the role of the corridors, while connecting fragmented areas of forest plantations. The works of modern scientists refer to forest biogeocenosis as a sign of a stable self-regulated plantation, therefore a forest shelterbelt can provide a complex of economic, environmental and social needs of society [10].

In forest shelterbelts, there are three trophic groups of plant producers: trees, shrubs and grasses. These are autotrophic organisms that form organic substances from inorganic substances during photosynthesis. Heterotrophs consume ready-made organic substances and are represented by herbivores (phytophages), predators (zoophages), and detritophages. It is the decomposers that decompose organic substances into minerals and complete the cycle of substances [11].

Forest shelterbelts create a stable plant cover, shape the climate, have a significant impact on the environment and are a shelter and habitat for plants, animals, fungi and viruses. The younger are the forest belts, the more diverse and intense the life in them is. Populations of different species that exist in forest shelterbelts are not separated, but are interconnected by various relationships. Relationships between the species that inhabit forest shelterbelts and are characterized by homogeneous living conditions form biocenoses. A sharp increase in the number of coenopopulations is observed in the ecotones of forest belts, which confirms the general ecological principle of the diversity of life on the border of the distribution of the phases or environments according to V.I. Vernadskyi [12].

Research results. Field shelterbelts are narrow linear plantations characterized by stability, productivity and durability in the formation of forest biocenosis in a certain territorially located biotope and under the conditions of the planned tree layer of the phytocenosis. An important role in the formation of field shelterbelts is played by the species composition and structure of field shelterbelts.

Field observations were conducted during 2023-2025 in Vinnytsia district of Vinnytsia region on black soils. 28 field shelterbelts were investigated and analyzed, which differed in their design: blowndown, openwork, dense, as well as in their location relative to the prevailing winds: main and auxiliary. The studied forest shelterbelts were presented as open, openwork and dense according to the proportion of the gap in their transverse state. Each type of forest shelterbelt has a corresponding structure and biometric indicators, as well as a positive impact on the condition and productivity of agroecosystems. According to another classification (location of shelterbelts relative to the direction of the prevailing winds) they are divided into main ones, which are located transversely to the direction of the prevailing winds, and auxiliary ones, which are located transversely to the main shelterbelts or along the direction of the prevailing winds.

During the research, it was found that the blowndown and open-cut forest shelterbelts are represented by the main and auxiliary ones, and the dense ones are only the main ones. It is this combination of different types of forest shelterbelts with each other that characterizes some of the differences between them. The analysis of the studied shelterbelts according to the characteristics of the structure – blown, openwork and dense, had shown that in main blowndown and openwork shelterbelts and in dense main shelterbelts the main species is lanceolate ash, and in dense main shelterbelts – sharp-leaved maple. And in all auxiliary blowndown forest belts, secondary tree species were not found, and in the main blown forest belts the secondary species was common oak. In openwork shelterbelts, the secondary tree species were found with oak, and in the auxiliary ones – common hornbeam. And dense main shelterbelts have a secondary species – lanceolate ash. (Table 1) % [13].

The single species in the main blowndown forest belt were heart-leaved linden (Tilia cordata Mill), in the main openwork forest belt – black locust (Robinia pseudoacacia L), wild cherry (Prunus avium L), wild plum (Prunus spinosa L), wild pear (Pyrus communis L); in the openwork auxiliary forest belt – wild cherry and wild pear, and in the main dense forest belt – common oak (Quercus robur L). There are no single tree species in the secondary openwork forest belt. The greatest species diversity of shrubs was found in the open main shelterbelt and was represented by: wild rose (Rosa canina L.), hazel (Corilus avellana L), undergrowth of common ash (Fraxinus excelsior Michx) and ash-leaf maple (Ácer negúndo). The open auxiliary shelterbelt has only one species of shrubs: black elderberry (Sambucus nigra). The dense main shelterbelt has two species of shrubs: black elderberry and undergrowth of common maple. All blowndown shelterbelts did not have shrubs in their species composition.

Table 1

Biological parameters of the structure of field shelterbelts of the Right Bank Forest-Steppe

Forest belt parameters	**Forest belt construction**				
	Blowdown		**Openwork**		**Dense**
View of the forest belt in the direction of the prevailing winds	Main	Additional	Main	Additional	Main
Main breed	lanceolate ash	lanceolate ash	lanceolate ash	lanceolate ash	Norway maple
Secondary breed	oak	-	oak	hornbeam	ash lanceolate
Single breeds	Heart-shaped linden	-	white acacia, wild cherry, wild plum wild pear	wild cherry, wild pear	oak
Bushes	-	-	Common rosehip, common lichen, ash maple	black elderberry	black elderberry undergrowth of common maple

The studies have shown that the greatest species diversity was in open-cut forest shelterbelts, and the least in blowndown ones. And all the main forest shelterbelts were more diverse in the species composition than the auxiliary ones. Observations of the metric parameters of the forest shelterbelts of the Right-Bank Forest-Steppe in the section of the blowndown, openwork and dense structures had shown that the largest number of rows of trees was found in the dense ones – 3 rows and was the smallest of all the studied forest belts. The main blowndown forest shelterbelt had – 5 rows of trees, and the auxiliary – 4 rows (Table 2). % [14].

The studied forest shelterbelts were created in the 60s-70s and therefore have some difference in the distance of trees in rows and between rows. Therefore, a comparison was also made of the distance between trees during the creation of the forest shelterbelts and the present time, so the designed and actual distances were investigated. The observations of the distance between the rows of trees in the shelterbelts had shown that the designed distances coincide with the actual ones. Therefore, the rows of trees are completely visible. And therefore, the distance between the rows of trees in the main blowndown forest belts is the smallest compared to all the studied types of shelterbelts and is 1.0 m. While in the blowndown auxiliary shelterbelts, the distance between the rows of trees was much greater and was 3.0 m. In the openwork main shelterbelts, the distance between rows of trees was 2.0 m, and in the auxiliary ones – 3.5 m, and this distance between rows was the largest among all the studied forest belts. In the dense shelterbelt, the distance between rows of trees was 2.5 m.

Table 2

Metric parameters of the structure of field shelterbelts of the Right Bank Forest-Steppe

Forest belt parameters	Forest belt construction				
	Blowndown		Openwork		Dense
View of the forest belt in the direction of the prevailing winds	Main	Additional	Main	Additional	Main
Number of rows of trees, pcs.	5	4	7	3	8
Distance between rows of trees, designed / actual, m	1,0 / 1,0	3,0 / 3,0	2,2 / 2,0	3,5 / 3,5	2,5 / 2,5
Distance between trees in a row, designed / actual, m	2,0 / 5,0	2,0 / 4,0	1,5 / 3,0	1,5 / 3,0	1,0 / 3,0
Width of the forest belt, m	7	12	15	9	20
Height of the forest belt, m	15	14	14	14	14
Trunk girth at a height of 1.3 m, cm	1,7	1,5	1,7	1,3	1,4

The distance between trees in rows of shelterbelts during the period of creation and the actual one has quite significant differences. For example, in the main shelterbelt, the designed distance between trees in rows is 2.0 m, while the actual one is 5.0 m. That is, out of five planted trees, only two survived. This is equal to 60% thinning of trees in rows. In the auxiliary shelterbelts, the designed distance between trees in rows was 2.0 m, and the actual one was already 4.0 m. That is, out of five planted trees, only 2.5 trees survived. The percentage of thinning of trees was 50%. In the openwork main and auxiliary shelterbelts, the designed and actual tree spacing in rows was the same and was 1.5 m and 3.0 m, respectively. The thinning of trees was also 50%. In the dense shelterbelt, the designed tree spacing in rows was 1.0 m, and the actual spacing was 3.0 m. That is, out of every 10 planted trees, only 3 survived. The thinning of trees in rows of dense shelterbelts is 70%.

Our research has shown that the greatest thinning of trees in rows of field shelterbelts was found in the dense main forest belt – 70% and the blowndown main forest belt – 60%. In the remaining forest belts, thinning of trees in rows was significant and amounted to 50%.[15, 16].

Conclusions and prospects for further research. Our research has established that the most species diversity of trees is found in open field shelterbelts, and the least in blowdown ones. All main field shelterbelts are represented by a greater species diversity of trees than auxiliary ones. In 80% of forest belts, the main species is lanceolate ash and in only 20% – sharp-leaved maple. Measures to adapt field shelterbelts to climate change should include: maintaining a stable field shelterbelt forest cover and increasing its area using tree and shrub species that are more resistant to global climate change; ensuring the preservation of the existing and increasing potential of biological diversity of field shelterbelts; rational combination of reforestation and afforestation of field shelterbelts using natural and artificial methods to ensure the stability of formed forest species; increasing the share of mixed forest species in field shelterbelts. Under the influence of global climate change, as well as a powerful anthropogenic factor, processes of death of coniferous plantations, in particular pine and oak, are observed. However, these forest species are not the main ones in field shelterbelts of the Forest-Steppe of Right-Bank Ukraine.

In the existing shelterbelts, the competitiveness of the species that are less demanding on moisture and more resistant to increased temperature will increase. Such species include black locust (Robinia), honey locust (Gleditsia triacanthos L.), maples (Acer L.) and lanceolate ash (Fraxinus lanceolata Borkh). But without the application of the adaptation measures, in the short and medium term, the existing shelterbelts may be lost. The constancy and durability of forest shelterbelts in agrolandscapes with a mosaic horizontal structure are due to the formation of forest biocenosis and provide the opportunity for succession processes and the formation of ecological niches.

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