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# Changes in the composition of grass and shrub layer plants in common oak stands since the closure of leaf canopy

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**Abstract**. Nowadays, there are threats of extinction of plant communities and individual plant species. Therefore, it is important to investigate the possibilities of restoring the composition of plants of different levels of forest phytocoenoses after clear-cutting in specific types of forest conditions. The purpose of the study was to establish the possibilities and features of restoring the species composition of plants of the grass and shrub layer, new growth and undergrowth after closing of canopies on common oak stands in fresh sugruds. Methods used: species accounting, comparison of species diversity at different sites, assessment of species abundance. It was established that the grass and shrub layer in closed forest stands consists of 54-57 species and it has a significant foliage cover – 60%. The base of the layer consists of 18-20 species. There

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is an increase with age in the value of the foliage cover of the main types of grass and shrub layer from 57-58% to 63-68%. It was found that the largest number of plants of the grass and shrub layer belongs to the forest ecological and coenotic group: in 9-10-year-old stands, 53.5% of species belong to the group, in 20-40-year-olds – 66.0%, and in 50-60-year-olds – 69.2%. It was found that the undergrowth consists of 4-6 species with a total closeness of 20-30% in crops of all age groups. The new growth consists of 6-8 species in forest stands of all age groups and their foliage cover ranges from 20-25%. The ratio of plants of different ecological and coenotic groups in oak stands of 50-60 years is quite close to overripe (130-140 years) natural stands. The practical significance of the study lies in the possibility of using the results in the practice of creating environmental protection facilities and justifying the systems of harvesting for the general use

**Keywords:** grass, shrubby and woody vegetation; foliage cover; Sorensen species similarity index; ecological and coenotic group

## INTRODUCTION

Forestry in Ukraine has always been aimed at increasing the productivity of forest stands to obtain more wood. With this in mind, pure stands of certain tree species were created, introductions were made, agrotechnical measures were taken to increase the intensity of forest crop growth, etc. Only over time did the forestry doctrines include provisions on ensuring the sustainability of forest ecosystems, the need to preserve biodiversity and ensure social functions. But even to this day, the practice of continuous logging for the general use and subsequent artificial afforestation of cutting areas continues.

According to V. Khryk and I. Kimeichuk (2021), in the forest management system, the most destructive for forest ecosystems are continuous logging, which leads to the destruction of the existing forest phytocoenosis and drastic changes in environmental conditions on the logging site. On logging sites there is: a sharp increase in the illumination of the soil and plants of the lower tiers of vegetation; significant damage to the soil cover and changes in many indicators that characterise its condition; destruction of soil animals, microorganisms, and flora; changes in the temperature conditions of air and soil, and their humidification modes. All of the above leads, in turn, to the disappearance or reduction of the spread of particularly shade-loving and shade-tolerant plants. Thus, O. Ostapchuk and O. Sovakov (2024) after a survey of 1-6 year-old logging sites in the Right-Bank Forest-Steppe, a generalisation was made that there was a sharp change in the species diversity and species of forest plants in comparison with ripe oak stands. Further changes in environmental conditions and vegetation cover are facilitated by silvicultural operations, which in the practice of forestry in Ukraine are carried out within one year after logging. Preparation of the soil for planting forest crops often consists in creating furrows. V. Tkachuk *et al.* (2019) found significant damage to blueberry thickets during the period of soil preparation for forest crops.

Notably, the deforestation of the territory of the state in the first half of the 20$^{th}$ century (before, during, and after the Second World War) significantly disrupted the age structure of the state's forests. The Public report of the Head of the State Forest Resources Agency of Ukraine for 2023 (2024) notes that the age structure is dominated by middle-aged plantings, the share of ripe and overripe stands is 18.7%. The average age of forests is more than 60 years, and there is a gradual ageing of forests, which leads to a deterioration in their sanitary condition. Thus, most of the forests of Ukraine are artificial. However, the Cabinet of Ministers of Ukraine approved the state strategy forest management of Ukraine until 2035 (2021), which provides for a gradual reduction in the total area of continuous logging, and also proposes to ensure the transition to close-to-nature methods of forestry with the establishment of forests of natural composition and structure. The latter involves the use of natural renewal of the main forest-forming tree species. This, according to P. Yavorovskyi *et al.* (2019), will ensure the conservation of biological diversity and sustainability of forest stands. V. Tkach *et al.* (2024), after a long study of the natural renewal of common oak after continuous logging, also state that the use of natural renewal is an important element in close-to-nature forestry. However, information is needed on the state of plant diversity in forest crops of different ages and the possibility of its restoration after continuous logging for the general use on a forest-type basis. Thus, in the Volyn and Zhytomyr Polissia, I. Ivanyuk (2021) investigated the restoration of plants of living ground cover in common oak crops in moist sugruds. The researcher established a very significant dynamism of plant composition after logging and creation of forest crops: disappearance and reduction of the spread of sciophytes and sciogeliophytes and the appearance of a significant number of sciophytes in open forest crops; gradual restoration of the presence of sciophytes in closed forest crops. O. Andrushchenko *et al.* (2018), who studied the species composition of plants of living ground cover in oak stands of different ages in the forest-steppe of Ukraine, also came to similar conclusions. L. Borsukevych (2023), who investigated floodplain forests of various species composition, concluded that artificial and overgrown oak forests have a weak ability to

self-heal and require measures to optimise their structure. Therefore, studies aimed at establishing the possible restoration of the composition of forest plants after continuous logging in various types of forest conditions are relevant.

One of the areas of research that would allow conducting a system of measures to implement the above-mentioned areas for the protection of biodiversity is objective information about its state. An important part of this is indicators on the impact of various anthropogenic factors on the distribution, productivity, and fruiting of plants in various natural and anthropogenic systems. Thus, studies aimed at identifying the dynamics of the composition of plants of living subsurface cover in stands of different ages after canopy closure, created after continuous logging, in different types of forest conditions are important. Their results, after comparing them with the materials of the plant species composition in sub-climactic forests, will help to make generalisations about the possibilities of restoration.

The purpose of the study was to establish the possibilities and features of restoring the species composition of plants of the grass and shrub layer, new growth and undergrowth after closing canopies of common oak crops in fresh sugruds.

## MATERIALS AND METHODS

The research was conducted on trial plots (TP) established in the forest plantations of state forestry enterprises (now branches "Luhyn Forestry" and "Radomyshl Forestry and Hunting Range" of the State Enterprise "Forests of Ukraine") in Zhytomyr Oblast, Ukraine. Trial plots were selected using a relational database of the Forest Fund of Ukraine as of 2017, and according to the accounting books of forest crops as of 2020 of specific forestry enterprises/forest districts. Technologies for creating forest crops were representative of the study region for a specific period, and the taxational characteristics of forest crops of the noted age groups were quite close (Table 1). This allows making certain generalisations about the course of the processes under study.

***Table 1**. Taxational and forestry characteristics of forest stands on trial plots*

| No. | Composition | Age, years | Height, m | Diameter, cm | Quality class | Stand density | Inventory, $m^3 \cdot ha^{-1}$ | Forest type |
|---|---|---|---|---|---|---|---|---|
| 13 | 10Co | 10 | 3 | 4 | II | 0.85 | 18 | $C_2$HOP |
| 14 | 7Co1Ep1Wb1Ch+Ba | 10 | 3 | 4 | III | 0.80 | 16 | $C_2$HO |
| 15 | 8Co2Nm | 10 | 3 | 4 | III | 0.80 | 18 | $C_2$HO |
| 16 | 8Co2Wb | 29 | 12 | 10 | I | 0.75 | 116 | $C_2$HOP |
| 17 | 10Co | 40 | 13 | 16 | III | 0.75 | 124 | $C_2$HOP |
| 18 | 10Co | 20 | 10 | 10 | II | 0.75 | 110 | $C_2$HOP |
| 19 | 10Co+Wb | 62 | 20 | 24 | I | 0.70 | 235 | $C_2$HOP |
| 20 | 8Co2Sp | 56 | 19 | 22 | I | 0.70 | 230 | $C_2$HOP |
| 21 | 10Co | 48 | 18 | 22 | I | 0.70 | 196 | $C_2$HOP |
| 1 | 9Co1Sp+Wb | 130 | 25 | 40 | 3 | 0.60 | 270 | $C_2$HOP |
| 2 | 8Co1Sp1Wb | 131 | 27 | 40 | 2 | 0.70 | 340 | $C_2$HOP |
| 3 | 10Co+Wb | 126 | 28 | 46 | 2 | 0.60 | 308 | $C_2$HOP |

***Source:** developed by the authors based on the relational database of the Forest Fund of Ukraine (2017)*

Trial plots measuring 100×100 m (1 ha) were established according to the description of O. Pakhomov and V. Petrushevskyi (2021). Within each TP, accounting areas (1×1 m) were established diagonally, where the foliage cover or presence of each plant species was determined according to the method described by I. Kuzmishina (2019). The study was conducted during April-October 2020. The study of the species composition of plant biodiversity in forest stands and overripe plantings was carried out according to identification guide by D. Dobrochayeva *et al.* (1999), and Latin names were specified in the Global Biodiversity Information Facility database (2024). In order to compare plant biodiversity in forest stands of different ages and compare it with data obtained in overripe plantings, the Sorensen similarity index adopted in geobotany described by A. Dzyba (2021) was applied according to the equation:

$$Iss = \frac{2C}{A+B}, \quad (1)$$

where I*ss* – index of species similarity; A and B – number of species in the trial plots that are compared; C – number of common species in the trial plots. In the course of the study, ecological and coenotic groups of plants described by I. Kovalenko (2024) were identified – forest, edge, meadow, swamp, and ruderal.

## RESULTS AND DISCUSSION

The grass shrub layer in closed forest crops (9-10 years old) consists of 54-57 species and it has a significant foliage cover of 60% (Table 2). However, the basis of the layer is 18-20 species.

***Table 1**. Main species of the grass and shrub layer in forest crops of common oak of different ages and their foliage cover in fresh sugruds (Quercetum franguloso (alni)-convallarioso-variaherbosum)*

| Name of shrub and grass species | Foliage cover of species (%) and their presence (+, -) in forest stands of different ages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 9-10 years old | | | 20-40 years old | | | 50-60 years old | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| *Convallaria majalis* L. | 8 | 10 | 8 | 8 | 13 | 10 | 20 | 20 | 20 |
| *Stellaria holostea* L. | 7 | 7 | 8 | 10 | 8 | 10 | 10 | 10 | 8 |
| *Pteridium aquilinum* (L.) Kuhn | 8 | 8 | 14 | 10 | 10 | 12 | 10 | 10 | 10 |
| *Clinopodium vulgare* L. | + | + | 1 | + | + | + | + | + | + |
| *Genista tinctoria* L. | + | 1 | + | + | + | + | + | + | + |
| *Veronica chamaedrys* L. | + | + | + | + | + | 1 | + | + | + |
| *Fragaria vesca* L. | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 |
| *Anemone nemorosa* L. | + | + | + | + | 5 | 7 | 8 | 8 | 12 |
| *Clematis recta* L. | 3 | 5 | 3 | 5 | 3 | 3 | 3 | 3 | 3 |
| *Calamagrostis arundinacea* (L.) Roth | - | - | - | 3 | 1 | 3 | 1 | 1 | + |
| *Carex montana* L. | + | + | - | 3 | 5 | 3 | 5 | 10 | 10 |
| *Festuca rubra* L. | 8 | 5 | 5 | 5 | 5 | 3 | 3 | 3 | 1 |
| *Brachypodium sylvaticum* (Huds.) P. Beauv. | + | + | - | + | 1 | + | - | + | - |
| *Poa angustifolia* L. | 5 | 5 | 5 | 5 | 5 | 3 | 1 | + | + |
| *Betonica officinalis* L. | 1 | 1 | + | 1 | 1 | + | + | 1 | 1 |
| *Agrostis vinealis* Schreb. | 7 | 5 | 5 | 5 | 3 | 5 | + | + | + |
| *Potentilla alba* L. | + | + | + | + | - | + | 1 | 1 | 1 |
| *Erigeron canadensis* L. | 5 | 7 | 7 | + | - | - | - | - | - |
| *Erigeron annuus* (L.) Pers. | 3 | 3 | + | - | - | - | - | - | - |
| *Hypericum perforatum* L. | 1 | + | + | + | + | + | + | + | + |
| *Calamagrostis epigeios* (L.) Roth | 1 | + | + | - | - | - | - | - | - |
| ***Foliage cover of the main species, %*** | ***58*** | ***58*** | ***57*** | ***58*** | ***61*** | ***61*** | ***63*** | ***68*** | ***67*** |
| ***Number of main species, units*** | ***20*** | ***20*** | ***18*** | ***19*** | ***17*** | ***18*** | ***17*** | ***18*** | ***17*** |
| ***Overall foliage cover of the layer, %*** | ***60*** | ***60*** | ***60*** | ***60*** | ***65*** | ***63*** | ***65*** | ***70*** | ***70*** |
| ***Total number of species, units*** | ***55*** | ***57*** | ***54*** | ***51*** | ***60*** | ***57*** | ***51*** | ***65*** | ***54*** |

***Source:** developed by the authors of this study*

The most widely distributed in terms of area are: *Convallaria majalis* L. with foliage cover – 8-10%, *Pteridium aquilinum* (L.) Kuhn – 8-14%, *Stellaria holostea* L. – 7-8%, *Festuca rubra* L. – 5-8%, *Agrostis vinealis* Schreb. – 5-7%, and *Poa angustifolia* L. – 5%. The first three species belong to the forest and their presence in older forest crops increases slightly – in *Convallaria majalis* – up to 8-13% in 20-40 year-old stands and 20% in 50-60 year-old stands, or stays at the same level. The following three species are those that prefer open areas and their presence decreases significantly with increasing age of forest stands. The latter also include *Erigeron canadensis* L., *Erigeron annuus* (L.) Pers., *Calamagrostis epigejos* (L.) Roth, *Hypericum perforatum* L. All of them probably became somewhat widespread before the closure of forest canopies, retained some presence after the closure of the latter, and disappeared in the following period. The dynamics of the spread of *Anemone nemorosa* L. in the common oak stands over time is noteworthy: absence in 9-10-year-old stands and reaching a foliage cover of 8-12% in 50-60-year-old stands. There is an increase in the foliage cover of the main species of the grass and shrub layer with age from 57-58% to 63-68% due to an increase in distribution of *Convallaria majalis*, *Carex montana* L., *Stellaria holostea* and *Anemone nemorosa* in older crops.

The number of sparsely distributed species in the grass and shrub layer is quite significant: in 9-10-year-old common oak stands – 23-24 species and their foliage cover is in the range of 2-3% (Table 3). The distribution of these species by area remains at the same level in older forest stands, and their number increases slightly. Thus, in 20-40-year-old oak crops, their number is 27-30 units, and for 50-60-year-olds – 23-34 units. A general trend can be noted: the increase in the number of species of the grass and shrub layer in older forest crops occurs due to the restoration of shade-tolerant and shade-loving species against the background of the disappearance of some light-loving ones. However, there is also the appearance of the latter in older forest stands. This may be conditioned by a number of reasons – the presence of a source of seed supply, the natural possibilities of seed entering a certain area (its volatility, displacement factors, etc.), and the presence of meadows, forest edges, sparse stands, the development of new growth and undergrowth. The necessary conditions appear both naturally (the death of trees, shrubs), and after logging and forest maintenance. It is

known that during the latter, not only some trees are selected, but also, more often, a significant part of the new growth and undergrowth is cut down. It is possible that the presence of a significant number of light-loving species in common oak stands of different ages is associated precisely with the system of forest sanitation.

***Table 3***. *Composition of sparsely distributed plants of the grass and shrub layer in common oak stands of different ages in fresh sugruds (Quercetum franguloso (alni)-convallarioso-variaherbosum)*

| Name of shrub and grass species | Foliage cover of species (%) and their presence (+, -) in forest stands of different ages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 9-10 years old | | | 20-40 years old | | | 50-60 years old | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| *Viola montana* L. | + | + | + | + | + | + | - | + | + |
| *Geum urbanum* L. | + | + | + | + | + | + | + | + | + |
| *Vicia sepium* L. | - | - | - | + | - | - | + | - | - |
| *Pilosella onegensis* Norrl. | - | - | - | + | + | + | - | + | + |
| *Galium tinctorum* L. | + | - | - | - | - | - | - | + | - |
| *Trifolium alpestre* L. | - | + | + | + | + | + | + | + | + |
| *Trifolium medium* L. | + | - | - | - | - | - | + | - | - |
| *Astragalus glycyphyllos* L. | + | + | + | + | + | + | - | + | + |
| *Primula veris* L. | + | + | + | + | + | + | + | + | + |
| *Euphorbia angulata* Jacq. | - | - | - | - | - | - | - | + | - |
| *Ranunculus auricomus* L. | - | - | - | + | + | + | - | - | - |
| *Ranunculus polyanthemos* L. | - | - | - | - | + | + | + | + | + |
| *Cruciata glabra* (L.) Opiz | + | + | + | + | + | - | + | + | + |
| *Taraxacum officinale* Weber ex FHWigg. | + | - | - | - | - | + | + | + | + |
| *Campanula trachelium* L. | - | - | - | - | + | - | - | - | - |
| *Campanula persicifolia* L. | + | + | + | + | + | + | + | + | + |
| *Dactylis glomerata* L. | - | - | + | - | + | + | - | - | - |
| *Lathyrus niger* (L.) Bernh. | - | + | + | + | + | + | + | + | - |
| *Tanacetum corymbosum* (L.) Sch.Bip. | - | - | - | + | + | + | - | + | + |
| *Serratula tinctoria* L. | - | - | - | + | + | + | + | + | + |
| *Viola hirta* L. | + | + | + | + | - | + | - | + | + |
| *Anthericum ramosum* L. | - | - | - | + | + | + | + | + | - |
| *Pulmonaria obscura* Dumort. | - | - | - | - | - | + | + | + | + |
| *Pulmonaria angustifolia* L. | - | - | - | + | + | + | - | + | + |
| *Pulsatilla patens* (L.) Mill. | - | - | - | + | + | + | + | + | - |
| *Dryopteris filix-mas* (L.) Schott | - | - | - | - | - | - | + | + | - |
| *Dryopteris carthusiana* (Vill.) H.P.Fuchs | + | + | + | + | + | + | + | + | + |
| *Scrophularia nodosa* L. | + | + | + | + | + | + | + | + | + |
| *Silene nutans* L. | - | + | + | + | + | + | - | + | + |
| *Silene vulgaris* (Moench) Garcke | - | - | - | - | - | - | + | + | + |
| *Platanthera bifolia* (L.) Rich. | - | - | - | + | + | + | - | + | - |
| *Viola reichenbachiana* Jord. ex Boreau | + | + | + | + | + | + | + | + | + |
| *Moehringia trinervia* (L.) Clairv. | - | + | - | - | + | - | + | + | + |
| *Stachys sylvatica* L. | + | + | + | + | + | + | + | + | - |
| *Lilium martagon* L. | - | - | - | - | - | - | - | + | + |

*Table 3. Continued*

| Name of shrub and grass species | Foliage cover of species (%) and their presence (+, -) in forest stands of different ages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 9-10 years old | | | 20-40 years old | | | 50-60 years old | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| *Potentilla argentea* L. | + | + | + | - | - | - | - | - | - |
| *Poa pratensis* L. | - | - | + | - | - | - | + | - | + |
| *Achillea millefolium* L. | + | + | - | - | - | - | - | - | - |
| *Hypochaeris radicata* L. | - | - | - | + | + | - | - | + | + |
| *Linaria vulgaris* Mill. | + | - | + | - | - | - | - | - | - |
| *Persicaria maculosa* Gray | - | - | + | - | - | - | - | - | - |
| *Pimpinella saxifraga* L. | + | + | + | + | + | + | - | + | + |
| *Lapsana communis* L. | - | - | - | - | + | - | - | + | + |
| *Mycelis muralis* (L.) Dumort. | + | - | - | + | + | + | - | - | - |
| *Leucanthemum vulgare* Lam. | + | + | - | - | - | - | - | - | - |
| *Saponaria officinalis* L. | - | + | + | - | - | - | - | - | - |
| *Daucus carota* L. | + | + | - | - | - | - | - | - | - |
| *Oreoselinum nigrum* Delarbre | + | + | + | - | + | + | + | + | + |
| *Carex leporina* L. | - | - | + | - | - | - | - | - | - |
| *Carex hirta* L. | + | + | + | + | - | - | - | - | - |
| ***Foliage cover of species, %*** | ***2*** | ***2*** | ***3*** | ***2*** | ***4*** | ***2*** | ***2*** | ***2*** | ***3*** |
| ***Number of species, units*** | ***23*** | ***23*** | ***24*** | ***27*** | ***30*** | ***28*** | ***23*** | ***34*** | ***27*** |

***Source:*** *developed by the authors of this study*

Plants listed in the Red Book of Ukraine were found in some of the surveyed areas: in 20-40-year-old and in 50-60-year-old stands – *Platanthera bifolia* (L.) Rich. and for 50-60-year-old stands – *Lilium martagon* L. The presence of these Red Book species was established only in half of the surveyed areas. Notably, during similar studies in 130-140-year-old natural oak forests of fresh sugrud, *Platanthera bifolia* was found in all surveyed plots and *Lilium martagon* in half of them.

For the purpose of comparing samples of plants of the grass and shrub layer in oak stands of different ages, the Sorensen index was used between each other and those obtained by the authors. Thus, this indicator increases from 0.67 (9-10-year-old stands) to 0.86 (50-60-year-old stands) (Ivanyuk & Ivanyuk, 2019). The latter indicates a gradual restoration of the composition of plants of the grass and shrub lever after continuous logging. Similar results were obtained by M. Vedmid *et al.* (2008), who investigated the recovery of grass and shrub level plants after continuous logging of ripe pine forests in fresh subors. Comparison of the species composition of plants of the grass and shrub layer of forest stands of different ages among themselves (determination of the Sorensen index) indicates that this indicator practically does not change with increasing age of forest crops: from 0.72 (comparison of 9-10-year and 20-30-year crops) to 0.70 (comparison of 9-10-year and 50-60-year crops).

Distribution of the species composition of grass and shrub layer plants by ecological and coenotic groups (Fig. 1) established that the largest number of them belongs to the forest (in cultures of all age groups). Thus, in 9-10-year – old stands, this group includes 53.5% of species, in 20-40-year-olds – 66.0%, and in 50-60-year-olds – 69.2%. The most common forest species in all trial plots were: *Anemone nemorosa*, *Stellaria holostea*, *Convallaria majalis*, *Carex montana*, *Pteridium aquilinum*. There was a gradual increase in this indicator with increasing age of planting. This may indicate the restoration of forest plants that disappeared during the period and as a result of cutting down the edificatory layer of tree species. The number of species in all other ecological and coenotic groups decreases with increasing age of forest crops. In cultures of 50-60 years, the ratio of plants of different ecological and coenotic groups is quite close to the data obtained in overripe (130-140 years) natural stands of common oak. All test areas, regardless of the age of the stand, contained *Convallaria majalis, Stellaria holostea, Fragaria vesca*, *Veronica chamaedrys*, *Betonica officinalis*, *Clinopodium vulgare*, *Genista tinctoria*, *Clematis recta*, *Festuca rubra*, *Poa angustifolia*, *Agrostis vinyl*, and *Pteridium aquilinum*. Surely these species can withstand quite long-term lighting, competition with light-loving species, and have effective methods of recovery.

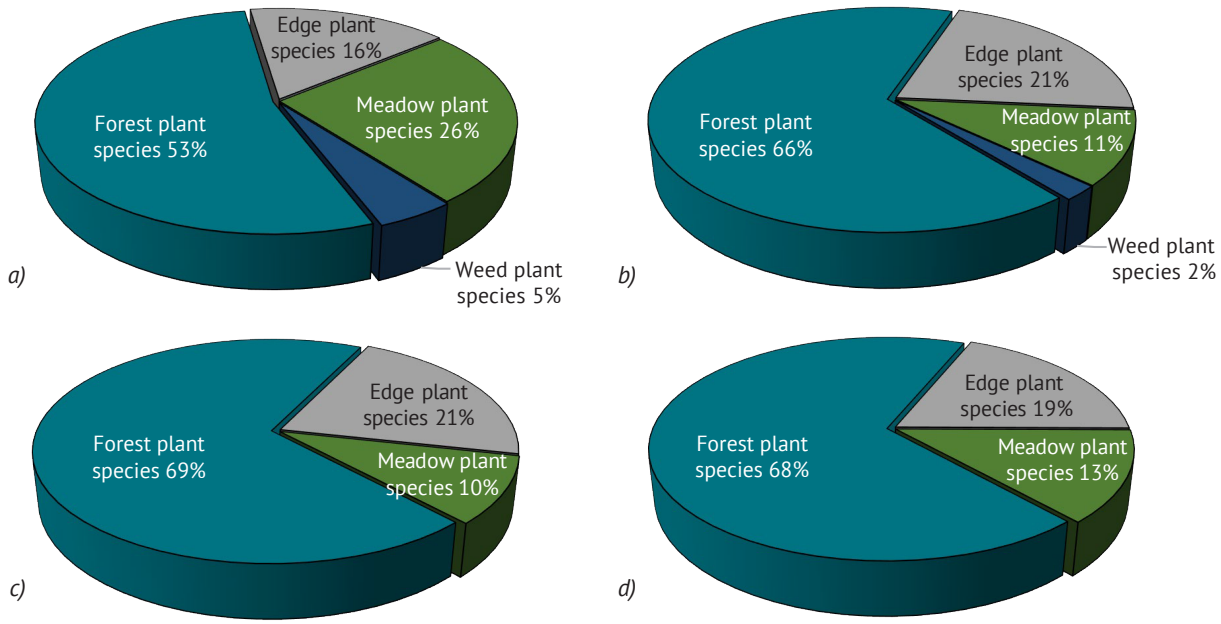


***Figure 1**. Distribution of grass and shrub layer plants by ecological and coenotic groups in common oak stands of different ages, in fresh sugruds*
***Note:** a – 9-10 years, b – 20-40 years, c – 50-60 years, and d – 130-140 years*
***Source:** obtained based on research*

The number of new growth and undergrowth species is also quite significant (Table 4). In the undergrowth, which consists of 4-6 species, the vast majority are two species: *Frangula alnus* Mill. and *Sorbus aucuparia* L. Their total foliage cover is 20-30% in forest crops of all age groups. Both species are shade-tolerant plants and recover well after deforestation and the creation of forest crops. The other 6 types of undergrowth are much less common in the area and are not found in all the surveyed areas. Attention is drawn to the distribution of the light-loving plant *Chamaecytisus ruthenicus* (Fisch. Ex Wol.) Klask in 9-10-year-old and 50-60-year-old crops. This may be due to its preservation after greater distribution in open forest crops and, possibly, the presence of small areas with some thinning of the stand (due to the reasons noted above) in older ones. Shade-tolerant *Corylus avellane* L. and *Euonymus verrucosus* Scop. are present in half of the surveyed areas and do not become widespread.

***Table 4**. Composition of new growth and undergrowth plants in common oak crops of different ages in fresh sugruds (Quercetum franguloso (alni)-convallarioso-variaherbosum)*

| Name of shrubby and woody species | Foliage cover of species (%) and their presence (+, -) in forest stands of different ages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 9-10 years old | | | 20-40 years old | | | 50-60 years old | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| **Undergrowth** | | | | | | | | | |
| *Frangula alnus* Mill. | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| *Sorbus aucuparia* L. | 10 | 10 | 10 | + | 10 | 10 | 10 | 10 | 10 |
| *Rosa canina* L. | + | + | + | + | + | + | - | + | - |
| *Rosa villosa* L. | - | + | - | + | - | + | - | - | + |
| *Rosa tomentosa* Sm. | - | - | - | - | + | + | - | - | - |
| *Chamaecytisus ruthenicus* (Fisch. ex Wol.) Klask. | + | + | - | - | - | - | 1 | + | + |
| *Corylus avellana* L. | + | + | + | + | - | - | + | + | - |
| *Euonymus verrucosus* Scop. | + | + | + | - | + | + | - | + | - |
| **Closeness of the undergrowth, %** | **30** | **30** | **30** | **20** | **30** | **30** | **30** | **20** | **30** |
| **Number of undergrowth types, units** | **5** | **6** | **4** | **5** | **5** | **6** | **4** | **6** | **4** |
| **Undergrowth** | | | | | | | | | |
| *Quercus robur* L. | 8 | 7 | 8 | 7 | 10 | 5 | 10 | 10 | 10 |
| *Populus tremula* L. | 10 | 10 | 10 | 10 | 8 | 10 | 10 | 8 | 10 |
| *Betula pendula* Roth. | 7 | 3 | 1 | 3 | 2 | 5 | + | 2 | 5 |

*Table 4. Continued*

| Name of shrubby and woody species | Foliage cover of species (%) and their presence (+, -) in forest stands of different ages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 9-10 years old | | | 20-40 years old | | | 50-60 years old | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| *Betula pubescens* Ehrh. | - | - | 1 | - | + | 5 | - | - | + |
| *Pyrus communis* L. | + | + | 1 | + | + | + | + | + | + |
| *Prunus cerasifera* Ehrh. | - | + | - | + | - | - | + | - | - |
| *Malus sylvestris* Mill. | + | + | - | - | + | + | + | + | + |
| *Pinus sylvestris* L. | + | + | + | - | + | + | + | + | + |
| *Carpinus betulus* L. | - | + | + | + | - | - | + | + | - |
| **Closing of the undergrowth, %** | **25** | **20** | **21** | **20** | **20** | **25** | **20** | **20** | **25** |
| **Number of undergrowth species, units** | **6** | **8** | **7** | **6** | **7** | **7** | **8** | **7** | **7** |

***Source:*** *compiled by the authors*

The new growth consists of 6-8 species in forest stands of all age groups and their foliage cover ranges from 20-25%. Three species are the most widespread: *Populus tremula* L., *Quercus robur* L. and *Betula pendula* Roth. The materials obtained during the research period somewhat complement the existing ideas about the impact of continuous logging on plant biodiversity, and also indicate a high probability of its restoration in forest stands over time. It was established that the value of the Sorensen index, when comparing the number of species in sub-climatic oak forests and in common oak stands of different ages, increases with increasing age of the latter from 0.67 (9-10-year stands) to 0.86 (50-60-year stands). The success of this restoration will depend on many factors: technologies for clear-cutting and creating forest crops; specifics of the latter's care before closure and thinning afterwards; location (distance, location to prevailing winds) of specific areas in relation to settlements and agricultural land, etc. Similar conclusions were reached by O. Orlov *et al.* (2021), who studied vegetation on objects of the nature reserve fund in the territory of Zhytomyr Polissia. According to V. Agiy et *al.* (20-19), timely inspection logging aimed at preserving common oak in Transcarpathia will allow forming mixed stands for the dominance of this particular tree species, and the delay in carrying out such logging in forest stands under the age of 10 years may lead to the loss of this main forest-forming tree species and its replacement with common hornbeam. P. Spathelf *et al.* (2023), who investigated the reforestation potential of oak stands in the forest-steppe of Ukraine (Central Podillia and Roztochchia), found that it is quite high, but further research is needed on the relationship between plants of the ground cover and undergrowth.

The possibility and success of restoring plant biodiversity may have its own characteristics in certain types of forest-growing conditions, which requires further similar studies on a forest-typological basis. Based on materials from M. Bondaruk and O. Tselishchev (2021), who investigated the rare component of forest coenoses of the West and Central Polissia Forestry District of Ukraine on monitoring sites, forest vegetation is characterised by forest type diversity and is represented by 23 forest site types, and vegetation – by 222 species. Indicators for rare plants in fresh sugruds only partially coincide with the results of this research. In the course of the study, two plant species were identified that are listed in the Red Book of Ukraine – *Platanthera bifolia* (L.) Rich. and *Lilium martagon* L., and the authors of the study describe only the latter. It was established that restoration of *Lilium martagon* occurred on 66.7% of the surveyed areas, and *Platanthera bifolia* – only on a third. The researchers also state that the determination of the places of growth of rare plant species should be done on a typological basis and then conduct monitoring observations (once every 5 years) or survey of allocated areas during the FSC certification of forestry branches.

Studies aimed at investigating the dynamics of plant diversity in the development of successions of natural sub-climactic forests, again on a forest-typological basis, are also necessary. It is known that the further development of such forests in many cases leads to changes in the composition of tree species of the first tier. These circumstances may lead to some or significant changes in the composition of the lower layers. P. Ustymenko *et al.* (2019) in their research, came to the conclusion that the introduction of an absolute conservation regime in sub-climatic forests quite often leads to complete degradation of these natural objects that were created for their conservation. They explain this fact by the fact that in their development, plant groups do not reproduce their own kind (there is a change in the structure of phytocoenoses – the composition of plants, the structure of the coenosis itself), and the direction and speed of these changes depends on numerous abiotic and biotic factors. Comparison of the above areas of research will significantly expand the understanding of the protection, conservation, and restoration of plant diversity in the forests of a particular region of Ukraine. M. Bondaruk *et al.* (2019) support the above proposals and propose a revision of some provisions of the reserve case, which, in their opinion, are based on conservative plant protection with an absolute reserve regime.

Thus, the results of the conducted studies confirm the importance of a typological approach in the study and monitoring of forest ecosystems for the conservation and restoration of plant biodiversity. It was established that continuous logging and features of forest sanitation can both contribute to and hinder the natural restoration of species, depending on the technologies used and growing conditions.

## CONCLUSIONS

As a result of the conducted studies, the species composition of grass and shrub layer plants in common oak stands of different ages was established: 9-10, 20-40, and 50-60 years. It was revealed that the most common plants include 18-20 species, among which forest plants have the greatest foliage cover – *Convallaria majalis* L. with foliage cover – 8-10%, *Pteridium aquilinum* (L.) Kuhn – 8-14%, *Stellaria holostea* L. – 7-8%, and types of open areas and forest edges – *Festuca rubra* L. – 5-8%, *Agrostis vinealis* Schreb. – 5-7%, and *Poa angustifolia* L. – 5%. Establishment of an increase in the foliage cover of the most common species of this layer with the age of forest crops. This is mainly conditioned by an increase in the areas of *Convallaria majalis*, *Carex montana* L., *Stellaria holostea*, and *Anemone nemorosa* L. The study also revealed a significant number of less common plants in stands of all age groups – 23-24 species in 9-10-year-old stands, 27-30 species in 20-40-year-old stands, and 23-34 species in 50-60-year-old stands. An increase in the number of species of the grass and shrub layer in older forest crops was observed due to the restoration of shade-tolerant and shade-loving species, which is also confirmed by calculations of the Sorensen index. When comparing the number of species in crops of different age groups with materials obtained in natural oak forests, its increase was found from 0.67 (9-10-year-old stands) to 0.86 (50-60-year-old stands). The distribution of the species composition of plants of the grass and shrub layer by ecological and coenotic groups was carried out, which revealed a significant number of plants at the forest edge, meadow, and weeds: in 9-10-year-old forest crops – 46.5%, in 20-40-year-old – 34.0%, and in 50-60-year-old – 30.8%. Their number was found to decrease with the age of common oak crops. The ratio of plants of different ecological and coenotic groups in cultures of 50-60 years is quite close to it in overripe (130-140 years) natural forests of common oak. The appearance of plants listed in the Red Book of Ukraine was also revealed – *Lilium martagon* L. and *Platanthera bifolia* (L.) Rich.) occurred on half of the surveyed areas of older forest stands. This coincides with the level of their presence in the surveyed areas of overripe natural forests.

The results of the study are important in terms of understanding the possibilities of restoring plants of the grass and shrub layer as a result of continuous logging for the general use in ripe forests with a predominance of common oak in fresh sugruds. Further research may focus on studying these processes in plantings of different species compositions on a forest-typological basis. Monitoring studies on the state of sub-climatic forests in protected areas are also promising.

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## CONFLICT OF INTEREST

None.

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# Зміна складу рослин трав'яно-чагарничкового ярусу у лісових культурах дуба звичайного з часу їх змикання

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**Анотація**. Внаслідок інтенсивної вирубки лісу у XX столітті в Україні порушена вікова структура лісових насаджень. Нині існують загрози зникнення рослинних угрупувань і окремих видів рослин. З огляду на це, актуальними є дослідження з вивчення можливостей відновлення складу рослин різних ярусів лісових фітоценозів після суцільної вирубки лісу в конкретних типах лісорослинних умов. Мета дослідження – встановлення можливостей і особливостей відновлення видового складу рослин трав'яно-чагарничкового ярусу, підросту та підліску після змикання культур дуба звичайного у свіжих сугрудах. Методи, які використовувались: облік видів, порівняння видового багатства на різних ділянках, оцінка рясності видів. Встановлено, що трав'яно-чагарничковий ярус у лісових культурах, що зімкнулися складається з 54-57 шт. і має значне проєктивне покриття – 60 %. Основу ярусу складають 18-20 видів. Спостерігається збільшення з віком величини проєктивного покриття основних видів трав'яно-чагарничкового ярусу від 57-58 до 63-68 %. З'ясовано, що найбільша кількість рослин трав'яно-чагарничкового ярусу відноситься до лісової еколого-ценотичної групи: у 9-10-річних культурах належить 53,5 % видів, у 20-40-річних – 66,0 % і у 50-60-річних – 69,2 %. Виявлено, що підлісок складається з 4-6 видів з сумарною зімкнутістю 20-30 % у культурах усіх вікових груп. До складу підросту входить 6-8 видів у лісових культурах всіх вікових груп і їх проєктивне покриття коливається у межах 20-25 %. Співвідношення рослин різних еколого-ценотичних груп у дубових культурах 50-60 років досить близьке до перестійних (130-140 років) природних деревостанів. Практична цінність досліджень полягає у можливості використання результатів у практиці створення природоохоронних об'єктів і обґрунтування систем рубок головного користування

**Ключові слова:** трав'яна, чагарникова та деревна рослинність; проєктивне покриття; індекс видової подібності Соренсена; еколого-ценотична група