# ECOLOGY

## Structural and functional role of the live ground cover in forest ecosystems of Ukraine

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**Abstract:** The article focuses on grass and subshrub layer of forests of Ukrainian Polissya, as well as its main structural features and functional role. Heterogeneity of flora of forest phytocenosis and a high floristic biodiversity are revealed with the use of comparative floristic analysis. Up to 5-6 ecological groups are allocated within each syntaxon in grass and subshrub layer, depending on the stand composition, mosaic relief and soil continuum. Undergoing of ontogenesis stages, type of morphogenesis, vital state and other factors respond to the changes in ecological and coenotic situation. Individual ecological amplitudes of forest grasses conform to the environmental regimes of the respective syntaxons, and the structure of the lower layers will retain its integrity and identity on the protected natural areas during the right economic exploitation of these forests. The composition and structure of the live ground cover largely influence the success of reduction process of tree layer.

***Keywords:*** *grass and subshrub layer, forest phytocenosis, Ukrainian Polissya.*

**Introduction.** The study of grass and subshrub layer of forests has more than a century of history. A. Khytrov (1908) in his classic work emphasizes that the plants forming grass and subshrub layer should be subject to thorough examination, as they play an important role in the forest life, and act as an indicator of its condition. Although the presence of forest stand is the main feature by which plant aggregation belongs to the category of forests, the maximum floristic richness and the greatest number of functional interactions are associated with the live ground cover. The live ground cover means "population of mosses, lichens, herbaceous plants and subshrubs, covering the soil under the canopy of forest" [11]. During the twentieth century, many publications were devoted to the results of the study of grass and subshrub layer. This layer was seen as antagonist to the mechanism of steady self-supporting of plants of tree layer or, on the contrary, as a functionally necessary part of forest phytocenosis [23, 29, 26, 6, 28 and many others]. Forest typology and floristic classification of forest phytocenosis largely rely on the nature of the live ground cover. Plants of grass and subshrub layer regulate the number and quality of woody species undergrowth [38]. In the last decades, different types of mathematical models [16] began to be used to study the condition and dynamics of the forest ground cover.

**Methodology.** Our objective was to analyze the main structural features of grass and subshrub layer and determine its functional role on the example of forests of Ukrainian Polissya on the basis of works of the classics of forest geobotany and forestry, research of the contemporary authors and our own data.

**Research. Center of floristic biodiversity**. The floristic richness of grass and subshrub layer depends on a forest type. In the forests, occupying the extreme position on the axis of environmental factors, i.e. in dry, waterlogged, poor soil etc., it is lower, but always remains considerably higher than the floristic richness of tree and subshrub layer. The common patterns are observed in the composition of flora of grass and subshrub layer. When shifting from the north to the south the proportion of dicotyledonous plants and the proportion of plant species with diclinous flowers [8] are increasing. Not only zonal, but also regional specificity of the species composition of grass and subshrub layer is its characteristics. For example, on the Central Russian upland *Aegopodium podagraria* is limited to its southern forests, and *Galeobdolon luteum* – to the northern forests [2].

In forest phytocenosss, floristic richness is maximal in grass and subshrub layer. The total number of grass and subshrub layer species in the forests of the former USSR is more than 1000 according to Yu. Alekseev and others (1988). Furthermore, the rare plant species protected under the Red Data Book of Ukraine and other territories in forest phytocenosss are, as a rule, components of grass and subshrub layer [40]. Based on 12-15 geobotanical descriptions in different forest types of the National Nature Park "Desniansko-Starogutsky" and adjacent territories, we have found that the proportion of grass and subshrub layer species is 65,7% in *Mercurialo perrenis-Quercetum roboris* association of *Querco-Fegetea* class, 63,7% in *Querco-Pinetum* association *of Quercetea robori-Petreae* class, and 73,5% in *Querco-Piceetum* association of *Vaccinio-Piceetea* class (Fig. 1). According to the literature data, the proportion of plant species of grass and subshrub layer in different forest types of Polissya is at the level of 50-80%.

Thus, a high floristic biodiversity of grass and subshrub layer in forest phytocenosis of Ukrainian Polissya and the heterogeneity of their flora are defined on the basis of comparative floristic analysis. In general, grass and subshrub layer in forests is a major centre of floristic diversity. Merganiu J. et al. [20] rightfully argue that "species diversity of grasses and subshrubs may be regarded as an indicator of the stability of forest ecosystems".

**Special structural part of forest phytocenosis**. Along with the floral diversity, the plants of grass and subshrub layer are characterized by the diversity of life forms [19]. Classes of Querco-Fagetea, Quercetea robori-petreaea and

 

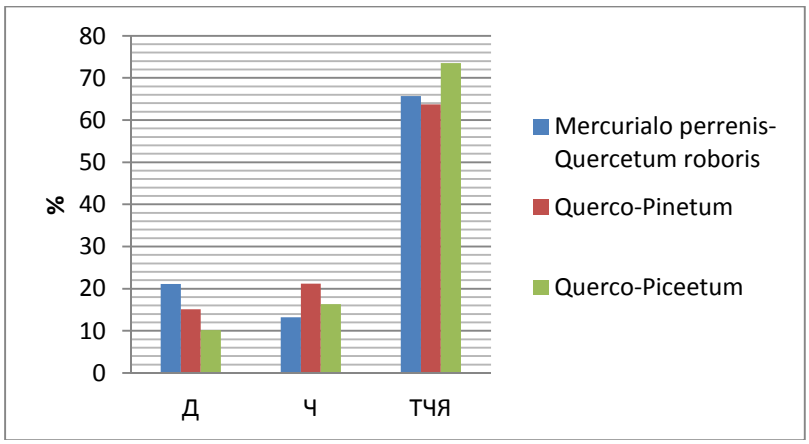


**Fig. 1.** Ratio in the number of species of wood (W), subshrub (S) and grass and subshrub layers (GSL) in Mercurialo perrenis-Quercetum roboris, Querco-Pinetum, Querco-Piceetum associations.

Vaccinio-Piceetea in the forest phytocenosis of Polissya, as can be seen from the diagram in Fig. 2, are characterized by the absolute predominance of hemicryptophytes. Geophytias come in the second place. They are mostly perennial grasses and subshrubs with vegetative reproduction. The composition of life forms in the group of grass and subshrub layer species of forest ecosystems demonstrates the high adaptability of these plant species to the growth environment – the plants with overwintering parts located deep in the soil or on the soil surface and covered with a layer of leaf litter are dominated.

A variety of the group of grass and subshrub layer species by area type is illustrated in Fig. 3. In the forest ecosystems of Novgorod-Siverske Polissya, genesis of plant species that comprise the core of grass and subshrub layer is associated with both European and Asian continents. Species of Eurasian genesis are dominated (of 38,7%). Area types of forest grasses and subshrubs reflect the geographical position of Ukraine and the region of research.

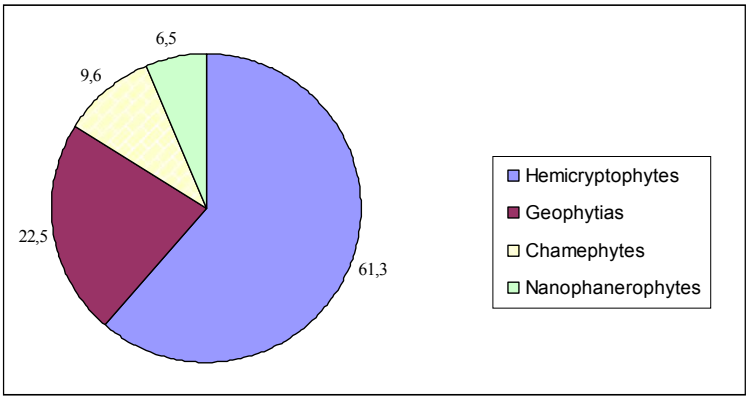


**Fig. 2.** The composition of life forms (in percentage) of a group of grass and subshrub layer specious of forest ecosystems

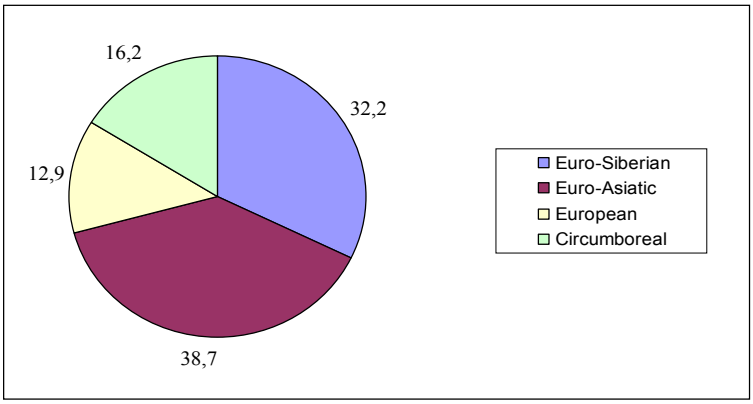


**Fig. 3.** A variety of group of grass and subshrub layer species by area type

L. G. Khanina and others [16] developed the system of coenotic groups, which consists of the following six forms: from species of spruce and spruce-fir forests (boreal form) to the species of coastal-water and underwater habitats, lowland and upland bogs (wetland form).

In general, 5-6 ecological groups are allocated within each syntaxon in grass and subshrub layer. Their number depends on the stand composition, mosaic relief and soil continuum. N. Y. Katz [15] was the first to suggest grouping species in forest phytocenosis by their ecological similarity. He used the ratio of conjugate occurrence. Currently, this problem can be solved on the basis of ecological scales [9]. Both methods are quite effective. For example, Table 1 presents a set of the six plant species of grass and subshrub layer, which is "blueberry group" according to N. Y. Katz. The calculation of ecological characteristics of this group of species has shown that it is really environmentally fairly homogeneous. The average module deviation for plant species of *Goodiera repens* only is one point of ecological scale, and it is less in other species.

**Table 1.** Ecological characteristics of group of species of blueberries

| Species | Ecological factor | | | | | | Average of the module |
|---|---|---|---|---|---|---|---|
| | Hd | Rc | Nt | Tm | Ae | Lc | |
| *Vaccinium myrtillus* | 12,0/-0,2 | 3,5/+0,8 | 4,5/-0,7 | 7,0/-0,1 | 8,0/-1,0 | 5,5/-0,4 | 0,53 |
| *Rhodococcum vitis-idaea* | 11,5/+0,3 | 4,5/-0,2 | 4,0/-0,2 | 6,0/+0,9 | 8,0/-1,0 | 4,5/+0,6 | 0,53 |
| *Linnea borealis* | 12,0/-0,2 | 3,5/+0,8 | 3,0/+0,8 | 5,5/+1,4 | 6,5/+0,5 | 4,0/+1,1 | 0,80 |
| *Goodiera repens* | 11,5/+0,3 | 7,0/-2,7 | 3,0/+0,8 | 8,0/-1,1 | 6,0/+1,0 | 5,0/+0,1 | 1,0 |
| *Melampyrum pratense* | 12,0/-0,2 | 3,5/+0,8 | 4,0/-0,2 | 7,5/-0,6 | 6,0/+1,0 | 7,0/-1,9 | 0,78 |
| *Lycopodium annotinum* | 12,0/-0,2 | 3,5/+0,8 | 4,0/-0,2 | 7,5/-0,6 | 7,5/-0,5 | 4,5/+0,6 | 0,48 |
| Mean by module | 11,8/0,23 | 4,3/1,02 | 3,8/0,48 | 6,9/0,78 | 7,0/0,83 | 5,1/0,78 | - |

**Note**: Hd – moisture mode, Rc – soil acidity, Nt – nitrogen content, Tm – thermal mode, Ae – soil aeration, Lc – luminance. Numerator is the optimal value, denominator is deviation from mean for the group of plant species.

**The ability to transform across time and space**. Change in species composition, life form and type of morphological organization during sungenetic or anthropogenic transformation of forest ecosystems is an important adaptive ability of plants of the lower forest layers [18]. A number of researchers see the root cause of the transformation of live cover of European Russia and adjacent territories from the Late Pleistocene to modern times in the change of functional groups of key species (edificators), occurred mainly as a result of anthropogenic influences [33]. There are fears that in the conditions of global warming the relationships between pollination and spread of diasporas in plants of the lower layers of forests and animals can be destroyed, and profound changes in grass and subshrub layer will have a negative impact on the forest sustainability in general [5]. Forest grasses and subshrubs are characterized by a great variety of methods of pollination and seed dispersal [24]. During the study of forest grasses, S. Barrett and others [3] showed that flowers of the majority of plant species were pollinated by insects, and in some species this was combined with autogamy. Various forms of bestiality, especially entomophily, predominate in the pollination of grasses and subshrubs of the forest ecosystems of Polissya. Zoochory also dominates in mechanisms of dissemination of fruits and seeds – in most cases fruits are juicy, seeds can have appendages, which are used by insects as food. This is also confirmed by literature data. The five ways of dispersion of seeds and fruits are implemented in *Carex pilosa and Mercurialis perennis*, the four ways – in Pulmonaria obscura and Viola mirabilis, and the three ways of dispersion occur in *Stellaria holostea, Polygonatum multiflorum, Asarum Aigerim, Aegopodium podagraria* [7].

Vegetative reproduction and ability to form clones are another characteristic of plants of the lower forest layer. According to the estimates of R. A. Karpinosova [14], in broad-leaved forests 47% of species belong to vegetative-motile plants of the live cover, 48% of species belong to vegetative-sedentary plants, and only 5% belong to vegetative-nonmotile plants.

It can be concluded that in all the plant species of grass and subshrub layer undergoing the stages of ontogenesis, morphogenesis type, life state, etc., can be changed as a reaction to the change of the ecological and coenotic situation [26]. At present during the formation of grass and subshrub layer in the forests, agricultural contamination of soil and atmosphere plays an important role as well [4].

**Indicative property of grass and subshrub layer**. The use of phytoindication methods enables to assess the ecological state in this forest phytocenosis by the composition of grass and subshrub layer more precise and integrated than any other method [22, 37, 9]. In a recent review, M. Diekmann [10] showed that phytoindication method is the best one to assess the ecological and phytocoenotic condition in any type of phytocenosis.

For example, phytoindication environmental analysis indicates that hygrophytes (about 2% of constant species), to a lesser extent, are presented in the oak forests of Ukraine. The number of xerophytes in these forests is larger (about 4%). The proportion of mesohygrophytes (11%) and mesoxerophytes (21%) is significantly higher, and mesophytes dominate (62%) [21]. According to our research data, a similar situation is observed in the mixed forests of Polissya. In general, in this region limiting ecological factors for the model species of boreal ecological and coenotic group are ombroclimatic factor, soil moisture and salt regime of soils.

The exact response of species of grass and subshrub cover to environmental conditions makes them important diagnostic indicators in classification of forest phytocenosis. Floristic composition of this layer is the basis for methods of forest type selection by Pogrebnyak and Vorobyov, and syntaxon classification methods by Braun-Blanquet. In the latter case, they are a part of the diagnostic and characteristic species on the level of syntaxons – union and association.

Overall, individual ecological amplitudes of forest grasses conform to the environmental regimes of the respective syntaxons, and during the efficient economic exploitation of these forests the structure of the lower layers will retain its integrity and identity on the natural protected areas.

**Impact on the initial stages of tree layer restoration**. The success of the tree restoration process is largely determined by the composition and structural features of the live ground cover. Grass and subshrub layer with a high total projective coverage turns out to be unfavorable for saplings of almost all species of woody plants. Especially negative factor is soil sodding with grains.

Modern studies [12] confirm that the composition and structure of grass and subshrub layer determine the direction of succession process in forest ecosystems. The common concept, which reveals functional and structural dependence of restoration process of woody plants on the live ground cover, has been developed by V. G. Sklyar [27]. According to this concept, which is called "forest restoration implementation", the undergrowth of woody species in the early stages of its growth is consistently "embedded" in certain layers of forest phytocenosis. At first, this occurs in the layer of mosses and lichens, then in grass and subshrub layer, and then in undergrowth layer and, finally, in adult forest stand. When "embedding" woody species undergrowth into each above-ground and soil layer, its deep morphological and physiological restructuring, associated with the changes in luminance, the amount of carbon dioxide in the air, humidity and chemistry of the soil, takes place. The most critical layers, which maximum mortality of seedlings and undergrowth is associated with, are the first two layers. V. G. Sklyar's concept of "forest restoration implementation" especially emphasizes the importance of the live ground cover for the stability of forest phytocenosis.

The impact of plants of grass and subshrub layer on the safety of seeds, their germination and development of seedlings of woody plants can be both favorable and adverse, in particular:

a) conditions of seed storage and germination of woody species depend on the nature of forest litter and structure of moss and lichen layer. Yu. A. Zlobin [39] proposed the concept of "ecological area" of seed germination in order to compare the ecological conditions of seed germination of different plant species. The establishment of areas of seed germination of forest grasses is a convenient and informative tool for analyzing those environmental factors that have the most pronounced effect on the seed germination process;

b) seeds, seedlings and growth processes of undergrowth are influenced by root exudates in the soil and gaseous emissions [35];

c) composition, chemical and physical properties of forest litter [30];

d) species composition of plants of grass and subshrub layer.

Biological pollution, manifesting as invasion of alien species into the natural grass and subshrub layer of forests, acts as an adverse factor in forest restoration. The invasion of *Alliaria petiolata* in forest phytocenosis of England had just such consequences [31]. It should be noted that there is a tough competition not only for ecological resources but also for pollinators and agents of diaspora transfer [32].

**Conclusions.** In general, grass and subshrub layer is an integral structural and functional part of any forest aggregation and determines its integrity and stability. And we can't but agree with C. G. Van Steenis [34] who has suggested the term "dryads", that is, the wood nymphs – the patronesses of trees in forests for plant aggregation of grass and subshrub layer.

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**Структурно функциональная роль живого надпочвенного покрова в лесных экосистемах Украины**

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**Аннотация.** Статья посвящена исследованию травяно-кустарничкового яруса лесов Украинского Полесья, проанализированы основные структурные особенности и установлена его функциональная роль. С помощью сравнительного флористического анализа установлена гетерогенность флоры лесных фитоценозов, но также и высокое флористическое биоразнообразие. В зависимости от состава древостоя, мозаичности рельефа и почвенного покрова, в пределах каждого синтаксона в травяно-кустарничковом ярусе выделяется до 5-6 экологических групп. Прохождение этапов онтогенеза, тип морфогенеза, жизненное состояние и др. реагирует на смену экологоценотической ситуации. Индивидуальные экологические амплитуды лесных трав отвечают экологическим режимам соответствующего синтаксона, и на естественных территориях, которые охраняются, как и при правильной хозяйственной эксплуатации этих лесов, структура нижних ярусов сохранит свою целостность и самобытность. Состав и структура живого надпочвенного покрова в значительной степени влияет на успеваемость возобновительного процесса яруса деревьев.

***Ключевые слова:*** *травяно-кустарничковый ярус, лесные фитоценозы, Полесье Украины.*