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Syntaxonomic adaptability of lower layer plants of the forest communities in the North-Eastern Ukraine

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In the North-Eastern part of Ukraine the forest communities occupy considerable area and have great ecological and economic value. In natural forests herbs and subshrubs maintain the canopy cover through the recovery mechanism when the undergrowth of woody plants by height constitutes a part of the herbaceous and subshrub layer. Cenoflora within the lower layers of mixed coniferous-broad leaved forests of the southern part of the Eurasian forest zone is a fairly complete structural unit, especially in the central parts of the moisture and soil fertility gradients. Syntaxonomic adaptability of the lower layer plants of the forest communities in the North-East of Ukraine is established, and their ecological and biological diversity is determined as a result of the researches conducted. A group of species of forest herbs and subshrubs by the ecological status takes an intermediate position because of their habitat versatility. The species of this group are characterized by the vegetative propagation along with the effective seed reproduction. The habitat versatility and combination of the two types of reproduction are the main reasons for a wide representation of the species of this group in different syntaxons. A high floristic biodiversity of the forest communities of the North-Eastern part of Ukraine and their flora heterogeneity are determined based on the comparative floristic analysis. The floristic difference between the two major classes of vegetation in this region is shown, and it is found that Querco-Fagetea class is characterized by a high nutrient status and good warming-up under slightly reduced soil moisture, whereas the main feature of Vaccinio-Piceetea class is low soil fertility.
Key words: forest ecosystems, forest conservation, syntaxonomic adaptability, North-Eastern Ukraine.

Introduction

Forests, occupying almost 40% of the planet's terrestrial surface, are the habitat of two-thirds of all terraneous species (Tkemaladze, 2016), and together with the oceans, have a high efficiency coefficient of photosynthesis (about 0.33%), and produce over 350 million tons of biomass per year that is about 60% of its total planetary production (Agess, 1982; Antonova, 1976; Voevodin, 2004; Kurnaev, 1968; Utkin, 1965; Shvydenko, 2008). The 11th World Forestry Congress held in Turkey in 1997, focused on the significant role played by non-timbered production of forests in the economy of rural areas both in the developed and developing countries, including national food security, provision of sustainable livelihoods, income and employment.

The Ukrainian forest ecosystems are of a significant public value. They are the source of a great deal of economic benefits, and simultaneously act as an ecological stabilizer throughout the state. The importance of forests for Ukraine is enhanced by their uneven distribution. The total amount of forest area in the country is 9490.9 thousand ha. But forests are mainly concentrated in two regions: 42% in the Carpathians, and 28.6% in Polissia. The forest area in Sumy region amounts to 403.8 thousand hectares, accounting for 17% of the region territory (Yakimchuk, 2013). Therefore, the forest utilization based on the principles of the forest self-preservation and ecological optimization is of significant importance for the North-East of Ukraine.

The demand for timber is the main factor determining the condition of forest ecosystems in the world. The need for arable land, resulting from the dynamics of population growth across the globe, ranks second. The share of the countries of Western Europe and North America accounts for approximately two-thirds of the world lumber production and consumption.

According to the data of the Food and Agriculture Organization of the United Nations for 2009, there is a reduction in the number of the territories covered with forests and thereby decrease in biomass supply in forests, and the amount of combined carbon in organic matter on the planet (Table 1).

By 2010 the total area under protection (natural reserves, wildlife sanctuaries, national parks, etc.) has amounted to about 1.9 billion hectares, or 14.5% of land area in the world. It is 35% greater than in 1990. About 13.5% of the global forest area belong to one or another category of the protected regions (Schmitt, 228).

Table 1. The condition of forests in the main countries and continents (The condition of forests ..., 2009)

Regions and countries	Forest area, ha×10^3	Annual average rate of forest area, %	Average biomass supply, t/ha	Average amount of combined carbon, g/ha
Ukraine	9.575	0.1	156	78
Russia	808.790	0.0	80	40
Belarus	7.894	0.1	137	68
Poland	9.192	0.3	195	97
Western Europe	131.763	0.45	102	50
Eastern Europe	43.042	0.35	173	86
In the world	3.952.025	–0.18	145	72

The list of the countries includes Ukraine and the bordering countries. The global indexes are shown for comparison.

The protected forest ecosystems are quite often the last barrier preventing from comprehensive developments (Chicas et al., 2016; Kibria et al., 2017), especially those related to the mining industry, oil-well drilling, infrastructure and large-scale agriculture. In general, the forest utilization is on a grand scale (Baral et al., 2016, Grilli et al., 2017, Bonsu et al., 2017). The global market volume of timber production is estimated at 300 billion dollars per year. 13 million hectares of forests disappear annually on our planet. The volume of deforestation in Ukraine goes beyond ecological limits. The diversified forest utilization has a significant negative impact not only on forest stand but also on all kinds of plants of the live ground cover of forests (Kovalenko, 2015).

The utilization of forest ecosystems is of integrated nature. The forest stand felling for timber plays the leading role. It is divided into several types. First and foremost, it is the principal use felling when all the mature forest stand is cut. After such cutting the reafforestation work is assumed to be performed on this territory. Another type is the intermediate use felling, which provides for partial cutting of certain tree species to create favorable conditions for the growth of the main species. The third type is the sanitation felling when the removal of dry and defective trees is carried out. Depending on the adopted technology, any of these types of felling leads to disturbances of the live ground cover. Sometimes, modern mechanization of logging operations completely destroys up to 2/3 of the plants of the herbaceous and subshrub layer, and changes the soil surface microrelief. The study of the ecological optimisation of these types of the forest ecosystem utilisation in the region is relevant and overriding priority.

In the North-Eastern part of Ukraine the forest communities occupy a considerable area, and are of a great ecological and economic value. Forests are fairly treated as holistic biological and ecological systems where two system-forming units are closely linked: 1) woody plants and; 2) subshrub and herbaceous plants of the lower layer. Thus, in natural forests herbs and subshrubs maintain the canopy cover through the recovery mechanism when the undergrowth of woody plants by height constitutes a part of the herbaceous and subshrub layer. While doing that, forest herbs and subshrubs perform an important diagnostic function in determining syntaxons under both their dominant and ecological-floristic classifications. Cenofloras within the lower layers of mixed coniferous-broad leaved forests of the southern part of the Eurasian forest zone are fairly complete structural units, especially in the central parts of the moisture and soil fertility gradients (Kovalenko, 2015). They are formed by a group of species that is often observed in different forest ecosystems. This is confirmed by the materials of Yu. A. Semenischenkov (Semenischenkov, 2010) on the example of zonal broad-leaved forests of the Southern Nonblack Soil Zone of Russia.

The stability of forest ecosystems depends on the biodiversity of forest herbs and the integrity of their floristic complexes (Yakubenko, 2003). However, the overall biodiversity and syntaxonomic importance of forest herbs are still understudied, and the existing unrelated materials require generalization. The lower layer plants of forest communities have long attracted the attention of researchers in connection with their economic, indicative and forest-stabilizing functions (Smirnova, 1987). The main focus of these researches is aimed at establishing the features of the life forms of plants of the forest lower layers, the seasonal development rate and ecological habitats (Goryshyna, 1972). In recent decades, many contemporary researchers have begun to study rare species and those species of a block of forest communities that are under protection (Sheliah-Sosonko, 2002). Since the late twentieth and early twenty-first centuries the lower layers of forest communities have been examined due to the syntaxonomic significance of their composition, as the development of the forest ecological and floristic classification based on the principles of Braun-Blanquet is associated with the identification of diagnostic types of syntaxons at all levels.

The necessary researches of syntaxonomic and typological nature have been already conducted on the forest ecosystems of Ukraine. The main syntaxons with the lists of diagnostic species are provided in the monograph of V. A. Solomakha (Solomakha, 2008). These species belong to different life forms, are distinguished by different duration of ontogenesis, and have the ecological optimum and phenological rhythms which do not coincide. However, there are no special studies of these features of the plants of the forest lower layers, which are the diagnostic species of certain syntaxons.

That is why the urgent task is the establishment of ecological and biological diversity and syntaxonomic adaptability of the lower layer plants of the forest communities in the North-East of Ukraine.

Material and methods

To solve the task set, we used the standard full geobotanical descriptions made during 2004-2015, Landolt's ecological scales and materials of geobotanical zoning with the consideration of modern methodological requirements. The research object was the group of the plants which were the most characteristic of the lower layers of forest communities – pine, oak and mixed forests, and the forest communities used in the dominant classification. They were compared with the groups of the diagnostic species of Querco-Fagetea and Vaccinio-Piceetea classes in the amount as specified in the works by J. Klika (Klika, 1955), V. Matushkewich (Matuszkiewicz, 2001) and V. A. Solomakha (Solomakha, 1996, 2008). When analyzing the forest herbs and subshrubs, both their specific taxonomic features and patterns of population organization were taken into account (Zlobin, 2009; Smirnova, 1998).

The results and discussion

Table 2. Comparative characteristics of diagnostic species of syntaxon classes and dispersed plant species of the North-East of Ukraine

Characteristics	Compared groups of plant species, %		
	diagnostic species of Querco-Fagetea class	diagnostic species of Vaccinio-Piceetea class	dispersed species
Environmental group			
- nemoral	81.3	0.0	61.5
- pratal	12.5	0.0	0.0
- boreal	6.2	100.0	38.5
Flowering periods			
- early	31.5	30.0	26.9
- medium	31.6	20.0	11.5
- late	36.9	50.0	61.6
Lifetime			
- perennials	100.0	100.0	100.0
Type of area			
- European	26.3	0.0	15.4
- Eurasian	52.6	20.0	38.5
- Eurosiberian	21.1	10.0	38.5
- circumboreal	0.0	70.0	7.6
Life form			
- geophytes	35.3	30.0	30.7
- hemicryptophytes	58.9	20.0	50.0
- chamephytes	5.8	20.0	11.5
- nanophanerophytes	0.0	30.0	7.8
Moisture regime			
- hygrophites	0.0	20.0	23.1
- hygromesophytes	17.6	10.0	19.2
- mesophytes	52.9	30.0	46.2
- xeromesophytes	29.5	30.0	7.0
- helophytes	0.0	10.0	0.0
- xerophytes	0.0	0.0	4.5
Nutrient status			
- megatrophs	41.1	0.0	50.0
- mesotrophs	52.9	10.0	23.1
- oligotrophs	6.0	90.0	26.9
Ecological optimum by Landolt's scale			
- moistening			
- soil fertility	2.8	3.3	2.4
- luminance	2.7	1,9	2.8
- temperature	2.4	2.3	2.1
	3.5	2.4	3.2

The Ukrainian Polissia flora has more than 2100 species of vascular plants, and contains apophytes and homerophobes. It has been formed from different centers, and generally refers to floras of migration type (Andrienko, 2006). This causes some heterogeneity of the flora of forest communities. The results of the bio-ecological, floristic and syntaxonomic analysis are shown in Table 2.

The analysis shows that the studied species of the live ground cover form two independent synusias: 1) forest subshrubs and dwarf subshrubs of *Vaccinium myrtillus, V. vitis-idaea* etc. 2) herbaceous perennial plants (*Aegopodium podagraria, Convallaria majalis*, etc.). We distinguished spring synusia (species of Scilla genus) within the last synusia. The syntaxons of Querco-Fagetea and Vaccinio-Piceetea classes are characterized by relatively close abundance of plant species with early, medium and late flowering periods, which obviously reduces competition for pollinators. On the contrary, the group of dispersed species was dominated by the plants of late flowering periods. Species differentiation by flowering periods has been discovered in a lesser degree. A clear contrast of the floristic composition of the diagnostic species of Querco-Fagetea and Vaccinio-Piceetea classes has been defined. The first of these classes is dominated by nemoral species, whereas the second class is dominated by boreal species. The group of dispersed species is dominated by nemoral herbs.

Querco-Fagetea class has the diagnostic species of the European and Eurasian distribution, while Vaccinio-Piceetea class has the diagnostic species of circumboreal origin. They are mostly mesophytes and xeromesophytes. The proportion of hygrophytes and hygromesophytes is greater in the group of dispersed species with the increased frequency of occurrence and significant abundance in the surveyed forests. The distribution of herbs, dwarf subshrubs and small subshrubs by the compared floristic groups has turned out to be relatively regular. Bulbous geophytes in their development are mainly adapted to the light phase in the forest life, and are more common in broad-leaved forests (Savoskyn, 1960). The ratio between the diagnostic species and soil fertility fully conforms to the nature of the selected syntaxons. Querco-Fagetea class is consisted of mega- and mesotrophs, whereas Vaccinio-Piceetea class is absolutely dominated by oligotrophs. The ecological scales enable to give more accurate characteristics of the compared floristic groups. The results obtained by the ecological scales of Landolt are presented in Fig. 1.

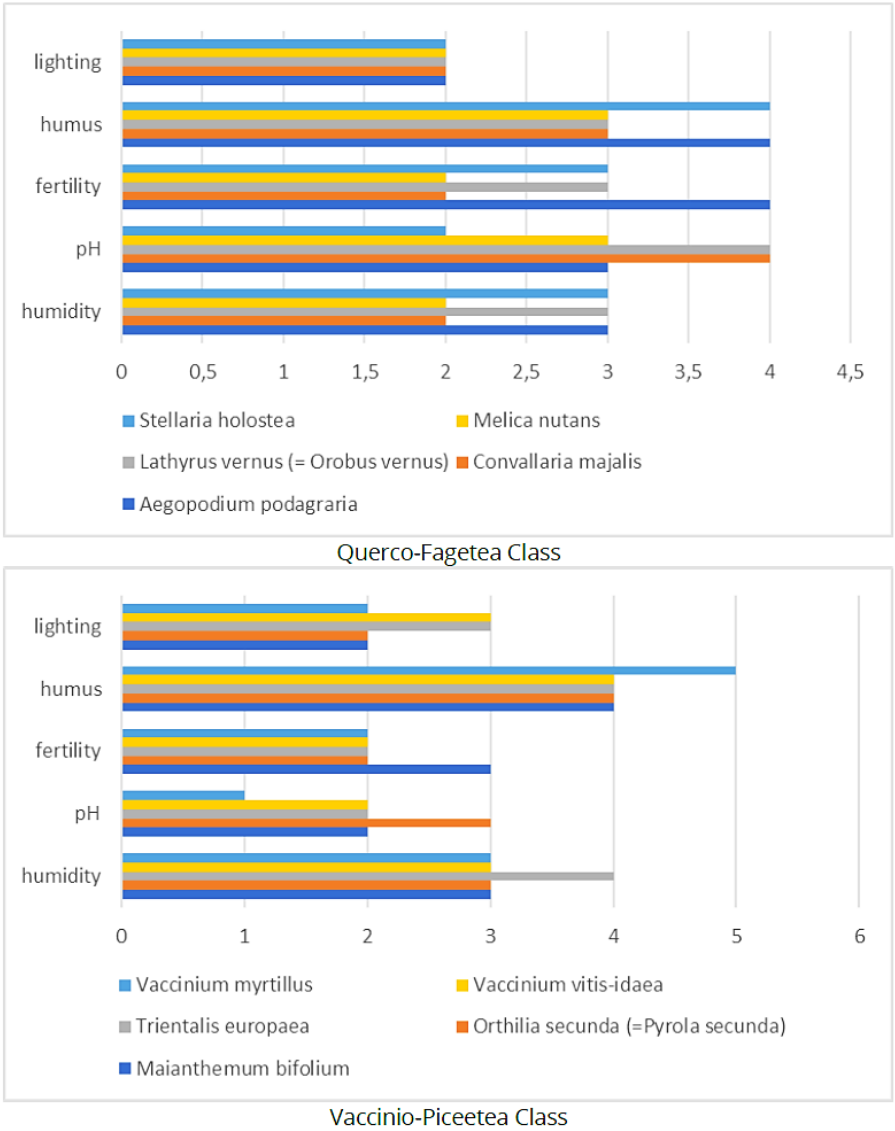

Fig. 1. Comparative characteristics of the investigated plant species by Landolt's ecological scales

In general, the generalization of the floristic groups of the forest communities in this region has revealed that the herbaceous plants of the lower layers are in the amplitude of moistening from middle dry to wet, in the amplitude of soil fertility from poor to middle rich, in the amplitude of luminance from shade to half-shade species, and in the amplitude of temperature - well-warmed habitats. This distribution of species is completely consistent with the geographical position of the area, its geomorphology and the history of forest use.

It has been simultaneously established that the ecological regimes in Querco-Fagetea and Vaccinio-Piceetea classes quite clearly differ as to their assessment of the ecological fitting of the diagnostic plant species. Moistening significantly (by 0.5 scales of Landolt) increases from Querco-Fagetea class to Vaccinio-Piceetea class. Vaccinio-Piceetea class is characterized by shifting towards moistening. It occurs due to two associations, which are characteristic of the studied region. These are the associations from Molinia caerulea and Vaccinium uliginosum (both hygrophilous), which are missing in Querco-Fagetea class.

The syntaxons of Vaccinio-Piceetea class take place in the habitat with the soil which is poorer (by 0.8) and bad warmed (by 1.1). In such a case, the trend of luminance at the level of the ground cover layer remains within the compared syntaxon species.

Nowadays, the level of anthropogenic load on forest ecosystems is commonly assessed by the so-called anthropogenic load coefficient. Its value of 3.1 to 3.5 is a threshold. Another criterion for assessing the territories is the forest cover percentage. The optimal level of forest cover in Ukraine is set at 20% of its territory (Yatsenko, 2014), which is about 3% higher than the actual level. The anthropogenic load on forests is high enough with the consideration of the population of Ukraine. The specific research and organizational work on the forest conservation in optimal ecological state is of particular necessity under these circumstances. This means the conservation of forest ecosystem in the integrity of its structural and functional properties. This can be achieved not only by the conservation of tree layer in forests, but also by the obligatory preservation of the holistic herbaceous and subshrub layer which is typical for this habitat.

The issue of protecting the herbaceous and subshrub layer condition in different forest ecosystems is of a holistic character, and requires the development of adequate methods based on the legislative acts of Ukraine and the researches of the specialists in the field of forest science and ecology. The effectiveness of protection increases significantly with the availability of the data of long-term monitoring of the condition of forest ecosystems and the predictions of their dynamics.

The protection of the forests of the North-East of Ukraine in their natural integrity, including the identity of the live ground cover, cannot be solved only through the creation of forest national natural parks, nature reserves or wildlife sanctuaries. A significant proportion of the region's biodiversity is linked with the forests of economic use. In this regard, one of the methods of the conservation of forest ecosystems and their herbaceous and subshrub layer is the change in technology and rules of procedure on the timber procurement, which should be based on the requirements of the ecological imperative and the maximum preservation of natural habitats. The ensuring of further reproduction of the horizontal and vertical structure of forest ecosystems in their integrity and patchiness plays an important role. And finally, all the key plant species and the main habitats which are characteristic of this forest type should be identified before forest sanitation. Such habitats should be fully preserved while conducting the final or any other felling operations.

Conclusions

A group of the species of forest herbs and subshrubs by ecological status is intermediate because of their habitat versatility. The plant species of this group are characterized by the vegetative propagation along with the effective seed reproduction. The habitat versatility and combination of the two types of reproduction are the main reasons for a wide representation of the species of this group in different syntaxons.

Thus, a high floristic biodiversity of forest communities of the North-Eastern part of Ukraine and their flora heterogeneity are determined based on the comparative floristic analysis. The floristic difference between the two major classes of vegetation in this region is shown, and it is found that Querco-Fagetea class is characterized by a high nutrient status and good warming-up under slightly reduced soil moisture, whereas the main feature of Vaccinio-Piceetea class is low soil fertility.

The relevant objective of further research is the study of the stability of forest herb and subshrub populations under progressive forest successions in the protected natural areas, and prior to anthropogenic loads in the forests of active economic use.

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