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Phytosociological and ecological peculiarities of *Festuca pallens* Host in Ukraine

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Key words: phytosociological assessment, phytoindication, dry grasslands, vegetation, Ukraine.

Ključne besede: fitocenološka ocena, fitoindikacija, suha travišča, vegetacija, Ukrajina.

Abstract
This article deals with phytosociological and ecological requirements of the vulnerable species *Festuca pallens* in Ukraine. Based on the analysis of 51 relevés, we have recognized the occurrence of *Festuca pallens* in three associations within the *Festuco-Brometea* class. Some communities where *Festuca pallens* occurs have transitional stages of succession to forest edge vegetation according to the expert system classification. In addition, we evaluated the ecological differences among occupied habitats using Didukh's phytoindication scales and concluded that the most important ecological factors are soil humidity, nitrogen content, soil aeration, salt regime, carbonate content, thermoregime, and climate continentality. Finally, we evaluated the threats to the existence of these communities with the presence of *Festuca pallens*, taking into account climate change and other impacts of anthropogenic activities (illegal mining, recreation, afforestation).

Izvleček
V članku obravnavamo fitocenološke in ekološke potrebe ranljive vrste *Festuca pallens* v Ukrajini. Z analizo 51 vegetacijskih popisov smo potrdili pojavljanje vrste *Festuca pallens* v treh asociacijah iz razreda *Festuco-Brometea*. Nekatere združbe, v katerih se pojavlja *Festuca pallens*, so po klasifikaciji z ekspertnim sistemom sukcesijski stadij prehoda v gozdni rob. Dodatno smo ovrednotili ekološke razlike med habitati s fitoindikacijskimi vrednostmi po Didukhu in ugotovili, da so najpomembnejši dejavniki vlažnost tal, vsebnost dušika, prezračenost tal, slanost, vsebnost karbonatov, toplotni režim in kontinentalnost klime. Za konec smo ovrednotili ogroženost združb z vrsto *Festuca pallens* v povezavi s klimatskimi spremembami in drugimi antropogenimi aktivnostmi (nedovoljeno rudarjenje, rekreacija, pogozdovanje).

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Introduction

Festuca pallens is a characteristic species of Central and Southern Europe (Markgraf-Dannenberg, 1980; Di Pietro & Catonica, 1999), but in Ukraine it is located at the eastern limit of its range and is clearly separated from the main part of the species' range by a disjunction. This species is extremely rare in the Ukrainian flora and is represented by a few isolated populations in a particularly restricted area, which naturally led to its endangerment and inclusion in the Red Data Book (Didukh et al., 2009). *Festuca pallens* is an obligate calcareous, xerophilous species that occurs on limestone and gypsum rocks, dry cliffs rock shelves and steep walls, and on chalk outcrops with low erosion. According to ecological strategy, this species is typically stress tolerant, although it also grows in shaded mesophitic communities that have developed on initial rendzic soils. Communities dominated by *Festuca pallens* are listed in the Green Book of Ukraine (2009) with the presence of *Carex humilis*, *Teucrium chamaedrys*, *Gypsophila fastigiata*, *Helianthemum canum*, *Aurinia saxatilis*, and steppe grass *Stipa capillata* (Zaverukha, 1978; Stoiko et al., 1998). According to the National Habitat Catalogue (Kuzemko et al., 2018), habitats with the occurrence of *Festuca pallens* are listed as T.1.2.2 Petrophyte steppes on carbonate substrata (Vasheniak, 2018) and as E:2.213 habitats with the dominance of *Festuca pallens* on carbonate slopes and outcrops (Korotchenko, 2011).

Therefore, the species and communities with their participation in Ukraine must be protected, which requires a meticulous and detailed study. This will allow to predict the behavior and the nature of further development of communities in modern conditions of environmental change. At the same time, such studies imply the conditions of existence and phytosociological peculiarities on the eastern border of their distribution in Ukraine, which differ from the characteristics of Central and Southern Europe. Finally, the culmination of these discoveries has led us to critically review the available information on the distribution of *Festuca pallens* and to study the ecological and phytosociological peculiarities of the respective communities, as well as to predict the possibility of future changes.

Systematic position

Festuca pallens belongs to a systematically complex group of narrow-leaved fescues, which is interpreted differently by authors. Consequently, the species has received different nomenclature in the course of scientific development. For example, in different periods the species was considered a subspecies or variety in the composition of *Festuca cinerea* s.l. (Rauschert, 1961; Toman, 1974; Rothmaler, 1994), *Festuca glauca* s.l. (Hackel, 1882; Kozłowska, 1926; Soó, 1956; Auquier P. & Kerguélen M., 1978), or as an independent species (Markgraf-Dannenberg, 1980; Šmarda et al., 2007), especially in the series *Psammophillae* (Pawlus, 1985). In Ukraine, *Festuca pallens* is represented by the typical subspecies of *Festuca pallens* Host subsp. *pallens*. *Festuca pallens* was first mentioned for the territory of Ukraine (at that time Galicia was part of Poland) in the works of Zapałowicz (1906) and A. Kozłowska (1926). There were very few works that mentioned *Festuca pallens*. Those that contained general systematic treatises on the genus were written by Alekseev (1975) and Tsvelev (1977) on the territory of the former USSR, and 2 works by Ukrainian authors (Tveretinova, 1977; Zaveruha, 1978). In addition, the vegetation with the occurrence of *Festuca pallens* was considered in the work of Onyshchenko (2001), describing the association *Minuartio auctae-Festucetum pallentis* within the order *Alysso-Sedetalia*, class *Sedo-Scleranthetea*, which occurs in the Nature Reserve "Medobory". Based on the above facts, we conducted a complex review of the known literature and herbarium data (Supplement 1) of sites with the occurrence of Festuca pallens and the geobotanical relevés of Festuca pallens communities (Figure 1).

Materials and methods

Study area

According to the geobotanical zoning, the study area includes the sub-province of Western Podillia, Central European province and Forest region, and is divided into three geobotanical districts: Opillia, Kremenets Ridge, and Volyn Upland (Figure 1, Appendix).

According to Zaverukha (1978), *Festuca pallens* is most widespread in the vicinity of Podillia (Ivano-Frankivsk region, Galych district). This species grows on extremely steep slopes of gypsum rock up to 10 meters high in various locations, while in other areas it mainly colonizes south-facing slopes. The area most densely colonized by *Festuca pallens* is on the open southern slopes with the participation of *Sedum hispanicum*, which is also rare for the continental Ukraine and is located at the eastern limit of its distribution. On the other hand, it was also found in shady, mesophytic communities with abundant mosses and ferns (*Cystopteris fragilis*, *Polypodium vulgare*), where *Festuca pallens* grows much less "vigorously" and forms small lawns, at times only in vegetative state, without generative organs, with green leaf blades in contrast to gray-leaved fescues growing in light habitats. In addition, it should be mentioned that *Festuca pallens* occurs on horizontal or gently sloping soils with floristically

Figure 1: Locations of the relevés with the presence of *Festuca pallens* in Ukraine.
Slika 1: Lokacije vegetacijskih popisov s navzočnostjo vrste *Festuca pallens* v Ukrajini.

degraded communities. The reason for this could be the accumulation of a considerable amount of soil enriched with organic matter in the swards. Such a substrate is gradually penetrated by other plant species that displace *Festuca pallens*. However, such a strategy is justified only on gentle slopes, whereas *Festuca pallens* forms long-term stable communities on steep cliffs (Medwecka-Kornaś & Kornaś, 1959). In addition, this fescue is found near trampled paths, where grass cover is sparse. Near Mezhyhirtsi in the Ivano-Frankivsk region there is a population of this species, which occurs in the form of small sites on gypsum rocks. Plowing of the area around the slope where *Festuca pallens* grows, as well as grazing, resulted in degradation of dry grasslands. In addition, ruderal elements invade and the rocks are overgrown by shrubs. In this situation, the lack of refuges and the species' inability to compete with other dominant species led to a significant reduction in its population (single individuals on the slope) and a decrease in the overall size of the plants. The third local population of *Festuca pallens* in Opillia was established near the village of Pidkamin (Ivano-Frankivsk region, Rogatyn district) on the steep, rugged gypsum walls of the northern and southern exposure at a height of 2–5 m, with the presence of *Sedum acre*, *S. hispanicum*, *Gypsophila thyraica* and *Thymus pannonicus*.

The Kremenets Ridge is one of the most important refugia where local populations of Festuca pallens have been preserved at the eastern limit of the species' range. It has been observed in a few places on Bona Hill (Zamkova Hill), Divocha Hill (Divochi Skeli) and Strakhova Hill. *Festuca pallens* is one of the dominant species in the petrophytic communities on these hills, which are mainly south-facing, with medium to very steep, open rocky slopes composed of Sarmatian-age limestones, characterized by a porous or multistepped surface form (Zaverukha, 1978). It is worth noting that the *Minuar-*

tio auctae-Festucetum pallentis association (Onyshchenko, 2001; Vinnichenko & Oliiar, 2004) on Divocha Hill is associated with the presence of both *Festuca pallens* and *Alyssum montanum*, *Artemisia campestris*, *Carex humilis*, *Dianthus arenarius* subsp. *pseudoserotinus*, *Festuca makutrensis*, *Minuartia aucta*, *Sedum acre* and *Thymus species* occurs. On Strakhova Hill, *Festuca pallens* grows together with *Carex humilis* and *Peucedanum oreoselinum* on the eastern slope with a slight inclination, which is partially overgrown by shrubs (*Frangula alnus*, *Euonymus verrucosa*) (Vinnichenko & Oliiar, 2004). The herb layer is formed by the dominant species *Carex humilis* and *Carex montana*, *Lembotropis nigricans*, *Peucedanum oreoselinum*, *Polygonatum odoratum*, *Pulsatilla patens*, *Ranunculus breyninus*, *Teucrium chamaedrys* and *Thalictrum minus*. In addition, these communities are atypical of *Festuca pallens* and rich in species of forest edge vegetation of the class *Trifolio-Geranietea* and in the successional stage of shrub vegetation (*Berberidion*).

A special habitat for *Festuca pallens* is a sand quarry in the town of Lysa near the village of Kulykiv (Ternopil region, Kremenets district). It is worth noting that *Festuca pallens* rarely grows on sandstone, even if it is very calcareous, except for a few isolated sites in Poland, where Jurassic sandstones are unusually hard and can serve as a stony substrate for fescue (Motyka, 1947). It is also interesting to note that *Festuca pallens* never grows on marls, which are essentially conglomerates (limestones and sandstones), whereas many plants can grow on both substrates. The most plausible explanation is that marls retain more moisture than sandstones, which is critical for *Festuca pallens*. Development of the quarry in Lysa is currently halted, but insignificant quarrying operations are occasionally carried out in its area. As a result, there is a whole range of transitional states from vegetation-free outcrops and pioneer communities to secondary shrub cover and coenotically unformed communities. The northern population of *Festuca pallens* was discovered on the Volyn Upland near the village of Mala Mylcha (Rivne Region, Dubno District), where the species occurs on chalk hills at elevations up to 350 m on the slopes of southern exposures. This fescue actively colonizes chalk outcrops and steppe communities with the dominance of *Carex humilis* and a sparse herb layer. *Festuca pallens* thus grows in different habitats under different conditions, but the most important characteristic is the carbonate content of the substrates and the sparse herb layer, even in disturbed or converted areas with weak ecological competition. It should be noted, therefore, that excessive recreational use or other anthropogenic impacts can trigger the extinction of a species. Such behavior is characteristic of many rare species, which we interpret as an "effect of repulsion of relics" (Didukh, 1988). In disturbed areas, *Festuca pallens* usually forms normal, full-sized populations; however, the viability of its individuals remains lower compared to plants of natural habitats. In particular, the vast majority of the species' morphometric indicators decline, including the number and height of generative stems and seed productivity under unfavorable conditions (Bednarska, 2011). Thus, seed reproduction is activated by the removal of coenotic pressure and competition from other species at the periphery of populations. Incidentally, this is observed both on natural landslides and outcrops and under disturbed conditions, which are sometimes completely uncharacteristic for *Festuca pallens*. When coenotic competition decreases, the behavior of the species is focused on recovery and establishment, while in closed coenoses it is about the self-sufficiency of the population.

Vegetation data collection

We have used 51 phytosociological relevés with a uniform plot size of 10 m² according to the Braun-Blanquet approach (Braun-Blanquet, 1964) with the modification of the EDGG method, personally collected in Ukraine in 2016 and 2020 with specific vascular plants, bryophytes and epigeic lichens. Nomenclature for vascular plant species is according to the Euro+Med Database checklist (http://www.emplantbase.org), while bryophytes are named according to Boiko (2008) and lichens according to Kondratiuk (1998).

Cluster analysis and expert system processing

Data were analyzed using JUICE software (Tichý, 2002). We used the modified TWINSPAN algorithm (Hill, 1979): three pseudospecies cut levels -0, 5, and 25, Whittaker method to distinguish clusters. Diagnostic species for each cluster were estimated based on the phi- coefficient (the threshold for fidelity greater than 25%) and tested using Fisher's exact test ($p \geq 0.01$) (Chytrý et al., 2002), with sizes of all groups standardized to equal size (Tichý & Chytrý, 2006). For identification of highly constant species, we set the threshold for constancy at more than 50% and for constant species at more than 25%. Class- and order-level identification was performed using the EuroVegChecklist Expert System (Mucina et al., 2016) and additionally using the Slovak Expert System (Janišová et al., 2007) to identify clusters with questionable syntaxonomy. All unidentified relevés or the relevés with low diversity of taxa (less than 10 taxa) were excluded from the dataset. As a result, we obtained 44 relevés, which we analyzed thoroughly.

Detrended Corresponded Analysis using Didukh's scales

A Detrended Correspondence Analysis (DCA) was conducted to evaluate the effects of environmental factors on plant communities. The phytoindication scales of Y. Didukh (Didukh, 2011) are comparable to other environmental indicator values (Ellenberg) and reflect amplitude indices of species characterized by the following dimensions: soil humidity (Hd – 23 grades), variability of damping (fH – 11 grades), soil acidity (Rc – 15 grades), total salt regime (Sl – 19 grades), carbonate content (Ca – 13 grades), nitrogen content (Nt – 11 grades), aeration of the soil (Ae – 15 grades), thermoregime of the climate (Tm – 17 grades), humidity of the climate (Om – 23 grades), continentality of the climate (Kn – 17 grades), cryoregime of the climate (Cr – 15 grades) and lightness in the community (Lc – 9 grades). Phytoindication values were passively projected onto a DCA graph. We used the program R (R Core Team, 2013) to visualize the DCA analysis.

Assessing of climate change impact on *Festuca pallens* communities

To assess the impact of climate change, point calculations of relevant indicators of 12 leading environmental factors were performed according to the scales and methods of Didukh (2021). Based on statistical processing of geobotanical data, the amplitude of their values for the corresponding syntaxon, average (X0), minimum (X0min) and maximum (X0max), as well as the correlation between their change for each of the factors, especially in relation to the temperature regime, were determined. Further measures were based on the fact that the increase in the average annual temperature by +1, +2, +2.5 and + 3.0 °C were determined on the basis of the correlation dependence equations and the corresponding values of the indicators for each of the factors were calculated. These values were taken as average values (X + 1, X + 2, X + 2.5 and X + 3), in relation to which the amplitude limits (±2σ) were calculated. The next analysis consisted in evaluating the overlap of the amplitudes of the obtained values in relation to the original, reflecting the current growth conditions of *Festuca pallens*. In the case of a direct ratio between the factors, this overlap was estimated in relation to the maximum (X0max), and in the case of an inverse ratio in relation to the minimum (X0min). If the mean values (X + 1, X + 2, X + 2.5 and X + 3) do not exceed the amplitude (X0min -X0max) and only the maximum (or minimum) values are outside this amplitude, then there is no threat to the existence of the species. If the mean values (X + 1, X + 2, X + 2.5 and X + 3) are outside the amplitude (X0min–X0max), but the minimum or maximum values (X + 1, X + 2, X + 2.5, and X + 3) are still within (X0min–X0max), there is a significant risk of habitat loss. If all values are outside the amplitude (X0min–X0max), then conditions have changed drastically, making the existence of *Festuca pallens* impossible and the original habitat has become extinct.

The next step was to evaluate the prediction of resistance, the nature of habitat development based on the behavior of species reflected in the environmental strategy of Grime (CRS). The calculation of the number of species of each type of strategy for specific relevés was carried out according to the formula: SS = S + (CS/2) + (SR/2) + (CRS/3); CC = C + (CS/2) + (CR/2) + (CRS/3); RR = R + (CR/2) + (RS/2) + CTS/3). The means and squared deviations (±2σ) for distinguished syntaxa, as well as the relationship between indicators were calculated: SS:CC; RR:CC; SS:RR and ratio C:S:R = 1.0:X:Y. The obtained indicators (as a percentage) of the ratios were plotted on the sides of Grime›s triangle, where the vertices correspond to 100%. On the line C-S the point is SS = 100-CC and the position is CC = 100CC/(CC + SS). On the line C-R the point CC = 100-RR, then the position is RR = 100RR/(RR + CC). On the line S-R, the point RR = 100-SS and the position is SS = 100SS/(SS + RR). The points were placed on the sides of the triangle and connected. On the basis of these numbers, the «centers of their masses» of the triangle were defined, corresponding to an intersection of its medians confined to the corresponding fields. On the basis of the average values of the ratios of the different types of strategies (%) for a certain type of syntaxon, a three-dimensional matrix was created, illustrating the possible way of development of the communities. This system of applying different methods allowed us to aim at a comprehensive evaluation of *Festuca pallens* communities and the ecological conditions of their existence, as well as to make certain predictions about possible changes, which is the core of developing measures for their conservation.

Results

The vegetation data of 44 relevés, consisting of 201 vascular plant and cryptogamic species, are divided into three main groups (Table 1), all belonging to dry grasslands of the class *Festuco-Brometea*, two associations of the order *Stipo pulcherrimae-Festucetalia pallentis*, *Galio campanulati-Poion versicoloris* alliance, and one syntaxon without clear syntaxonomic affiliation.

Table 1: Synoptic table of communities in which *Festuca pallens* (Ukraine) occurs, indicating the constancy of species expressed by their percentage frequency to the respective three clusters. Shaded species are ranked by decreasing constancy: dark shading ≥50%, light shading ≥25%. Phi coefficient values are not shown, but species with phi- value greater than 0.25 are accepted as differential for the alliances. Species of each syntaxon with a constancy of 15% or less as well as other taxa with a constancy of 15% or less are not shown in the table.

Tabela 1: Sinoptična tabela združb z vrsto *Festuca pallens* v Ukrajini. Prikazana je stalnost vrst s frekvenco v odstotkih v treh klastrih. Zasenčene vrste so urejene po padajoči stalnosti: temno osenčeno ≥ 50%, svetlo osenčeno ≥ 25%. Vrednosti fi koeficienta so prikazane samo za vrste z vrednostjo večjo od 0,25, kar smo upoštevali kot razlikovalnice za zvezo. Značilne vrste za posameze sintaksone s stalnostjo, manjšo od 15%, in ostale vrste s stalnostjo, manjšo od 15%, v tabeli niso prikazane.

Number of relevés	18	15	11
Cluster	1	2	3
Festuca pallens	100	100	100
Ass. *Schivereckio podolicae-Seselietum libanotidis*			
Gypsophila thyraica	61	7	45
Thymus pannonicus	50	.	18
Campanula rotundifolia	50	13	.
Astragalus onobrychis	33	20	9
Arabidopsis arenosa	33	0	18
Ass. *Minuartio auctae-Festucetum pallentis*			
Clinopodium acinos	6	80	9
Thymus serpyllum	.	73	18
Alyssum gmelinii	.	67	9
Minuartia setacea subsp. *setacea*	6	67	18
Medicago falcata	22	53	9
Centaurea stoebe	11	53	18
Anthyllis vulneraria	6	33	.
Saxifraga tridactylites	.	33	.
Silene eugeniae	11	27	.
transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea*			
Anthericum ramosum	.	27	82
Teucrium chamaedrys	6	7	64
Stipa capillata	.	7	55
Salvia verticillata	11	.	45
Geranium sanguineum	11	.	45
Cytisus paczoskii	.	.	45
Galium boreale subsp. *exoletum*	17	13	45
Teucrium montanum	6	20	45
Thalictrum minus	.	13	45
Galium mollugo	11	.	36
Pimpinella saxifraga	.	7	36
Stachys recta	.	7	36
Cytisus albus	6	.	27
Lembotropis nigricans	.	.	27
All. *Galio campanulati-Poion versicoloris*, Ord. *Stipo pulcherrimae-Festucetalia pallentis*			
Potentilla incana	39	67	73
Allium lusitanicum	67	53	27
Sedum acre	50	80	9
Helianthemum canum	11	33	73
Carex humilis	11	33	64
Melampyrum arvense	11	33	9

Number of relevés	18	15	11
Inula ensifolia	17	7	27
Galium glaucum	17	.	27
Iris aphylla subsp. *hungarica*	11	.	18
Sempervivum ruthenicum	22	7	.
Cl. *Festuco-Brometea*			
Asperula cynanchica	61	40	55
Artemisia campestris	56	67	9
Festuca stricta subsp. *sulcata*	39	47	9
Campanula sibirica	28	27	36
Elytrigia intermedia	28	40	36
Euphorbia cyparissias	56	20	73
Arenaria serpyllifolia	33	33	.
Scabiosa ochroleuca	.	67	55
Koeleria macrantha	39	33	27
Hypericum perforatum	11	7	36
Euphorbia seguieriana	11	7	36
Other species			
Veronica spicata	33	27	18
Asplenium ruta-muraria	28	27	.
Galium verum	22	13	27
Echium vulgare	6	20	27
Vincetoxicum hirundinaria	.	20	27
Centaurea phrygia	.	.	27
Hieracium umbellatum	22	.	.
Geranium robertianum	17	7	.
Peucedanum cervaria	17	7	9
Seseli libanotis subsp. *intermedium*	17	.	9
Cryptogam species (in alphabetical order)			
Abietinella abietina	22	67	27
Barbula unguiculata	.	40	9
Brachythecium albicans	22	.	.
Bryum argenteum	.	20	18
Bryum kunzei	.	67	18
Ceratodon purpureus	11	53	9
Cladonia pocillum	.	20	9
Cladonia pyxidata	17	13	9
Collema tenax	17	27	9
Ditrichum flexicaule	.	60	27
Encalypta vulgaris	6	47	9
Homalothecium lutescens	.	20	9
Homalothecium sericeum	.	47	9
Hypnum vaucheri	11	27	.
Pseudocrossidium hornschuchianum	.	20	.
Rhytidium rugosum	.	27	.
Tortula calcicolens	0	27	.
Tortella inclinata	.	33	27
Tortella tortuosa	.	13	27
Tortula ruralis	6	47	18
Weissia sp.	.	.	27

Figure 2: Pictures of the communities with the presence of *Festuca pallens*. a) *Minuartio auctae-Festucetum pallentis,* Krements Ridge, Divochi Skeli Hill, Ukraine; b) *Schivereckio podolicae-Seselietum libanotidis,* Velyki Goldy Hills, c) transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea,* Krements Ridge, Strakhova Hill, photos made by Iuliia Vasheniak.

Slika 2: Slike združb z vrsto *Festuca pallens*. a) *Minuartio auctae-Festucetum pallentis,* greben Krements, hrib Divochi Skeli, Ukrajina, foto Vasheniak Iullia; b) *Schivereckio podolicae-Seselietum libanotidis,* hribovje Velyki Goldy, c) prehodna združba med razredoma *Festuco-Brometea* in *Trifolio-Geranietea,* greben Krements, hrib Strakhova, fotografije Iuliia Vasheniak.

On Figure 2 some examples of communities of distinguished vegetation types are presented.

Ecological peculiarities of the communities with the presence of *Festuca pallens*

As we can see from Figure 3, three syntaxa were clearly distinguished on the DCA visualization. The main axis (DCA 1) distinguishes the differences of *Minuartio auctae-Festucetum pallentis* association compared to other syntaxa

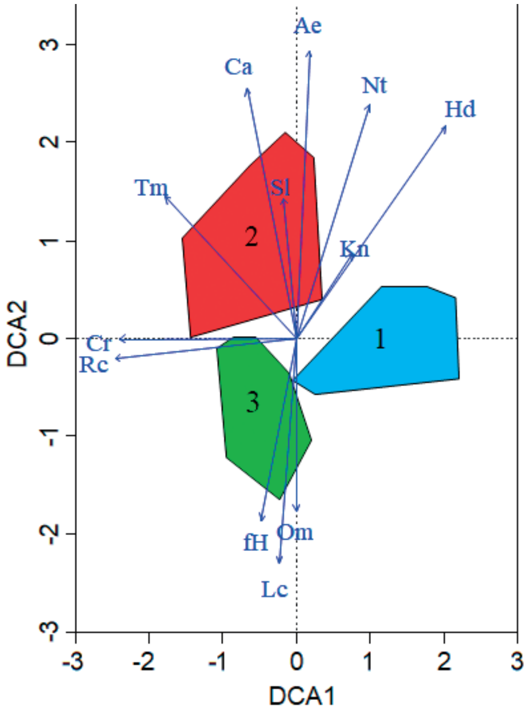

Figure 3: Detrended Correspondence Analysis of the distinguished syntaxa. 1-*Schivereckio podolicae-Seselietum libanotidis, 2-Minuartio auctae-Festucetum pallentis,* 3-transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea.* Acronyms: Hd (soil humidity), fH (variability of damping), Rc (soil acidity), Sl – total salt content in soil, Ca – calcium/magnesium content in soil, Nt – nitrogen content in soil, Ae – soil aeration, Tm – thermal climate, Om – ombroregime, Kn – continental climate, Cr – cryoclimate, Lc – light.

Figure 3: Korespondenčna analiza z odstranjenim trendom obravnavanih sintaksonov. 1-*Schivereckio podolicae-Seselietum libanotidis, 2-Minuartio auctae-Festucetum pallentis,* 3- prehodna združba med razredoma *Festuco-Brometea* in *Trifolio-Geranietea.* Okrajšave: Hd (vlažnost tal), fH (variabilnost vlažnosti), Rc (kislost tal), Sl – vsebnost soli v tleh, Ca – vsebnost kalcija/magnezija v tleh, Nt – vsebnost dušika v tleh, Ae – prezračenost tal, Tm – toplota klime, Om – ombrorežim, Kn – kontinentalnost klime, Cr – krioklima, Lc – svetloba.

according to most environmental factors (soil humidity, nitrogen content, aeration of the soil, salt regime, carbonate content, thermoregime, and continuity of climate) and transitional communities, which include different stages of digression according to variability of damping, humidity of the climate and light in the community. Although the second axis (DCA 2) does not show significant differences between the associations, it reflects the difference between the *Schivereckio podolici-Seselietum libanotidis* association and the previous ones in terms of soil acidity and cryoregime of the climate. The transitional communities are located along the vectors of variability of damping, humidity and light in the community.

Table 3: Mean indicator values, amplitude of environmental factors and their possible changes at increase of average annual temperatures by +1, +2, +2.5 and +3.0 °C. The minimum values, in relation to which the limits are calculated, are marked by a green color, and the maximum values by a blue color. The zone of increasing risk is marked by a yellow color; the risk of loss is marked by a red color. Variants were calculated depending on the degree of correlation between indicators of different (A) and petrophytic types (B) of Western Podillia groups.

Table 3: Povprečne indikatorske vrednosti ekoloških dejavnikov in njihove možne spremembe ob povprečnem porastu temperature za +1, +2, +2,5 and +3,0 °C. Minimalne vrednosti, s katerimi smo izračunali mejne vrednosti, so označene z zeleno, maksimalne vrednosti z modro. Razpon povečanja ogoženosti je obarvan z rumeno, območje z možnostjo izgube pa z rdečo. Različice smo izračunali v odvisnosti od razmerja med indikatorji različnih (A) in petrofitskih (B) tipov za skupine iz zahodnega Podillia.

	averaged	min	max	T-0	T+1	%	T+2	%	T+2,5	%	T+3	%
Tm-A	9.21	8.67	9.75	9.21	9.9	102	10.6	109	10.9	112	11.3	116
Tm-B	9.21	8.67	9.75	9.21	9.86	101	10.5	108	10.8	111	11.2	114
Cr-A	8.71	8.08	9.33	8.8	9.12	97.7	9.43	101	9.59	103	9.75	105
Cr-B	8.71	8.08	9.33	8.8	9.11	97.6	9.49	102	9.65	103	9.86	106
Kn-A	8.69	7.97	9.42	8.74	8.98	95.4	9.22	97.9	9.34	99.2	9.46	100
Kn-B	8.69	7.97	9.42	8.74	8.97	95.2	9.2	97.6	9.29	98.6	9.43	100
Om-A	12	11.2	12.8	12	11.3	99.6	10.5	106	10.2	110	9.8	115
Om-B	12	11.2	12.8	12	11.2	99.8	10.7	105	10.5	107	10.1	111
Hd-A	8.77	7.8	9.73	8.83	8.16	95.7	7.5	104	7.17	109	6.83	114
Hd-B	8.77	7.8	9.73	8.83	8.19	95.2	7.57	103	7.3	107	6.94	112
Fh-A	6.13	5.27	6.99	6.19	6.33	90.7	6.48	92.7	6.55	93.7	6.62	94.8
Fh-B	6.13	5.27	6.99	6.19	6.33	90.5	6.46	92.5	6.52	93.3	6.6	94.4
Nt-A	4.19	3.37	5.02	4.25	3.95	85.2	3.66	92	3.51	95.9	3.36	100
Nt-B	4.19	3.37	5.02	4.25	3.97	84.8	3.69	91.3	3.57	94.3	3.41	98.8
Ae-A	5.2	4.6	5.8	5.23	4.99	92.3	4.75	96.9	4.64	99.3	4.51	102
Ae-B	5.2	4.6	5.8	5.23	5	92	4.78	96.4	4.68	98.3	4.55	101
Rc-A	8.7	7.96	9.44	8.7	9.32	98.7	9.93	105	10.2	108	10.5	112
Rc-B	8.7	7.96	9.44	8.7	9.28	98.3	9.86	104	10.1	107	10.4	111
Sl-A	8	7.03	8.96	8.01	8.56	95.5	9.1	102	9.37	105	9.65	108
Sl-B	8	7.03	8.96	8.01	8.57	95.7	8.98	100	9.15	102	9.38	105
Ca-A	8.91	7.45	10.4	8.88	9.41	90.7	9.93	95.8	10.2	98.3	10.5	101
Ca-B	8.91	7.45	10.4	8.88	9.43	90.9	9.82	94.7	9.99	96.3	10.2	98.5
Lc-A	7.64	7.24	8.04	7.61	7.79	96.9	7.96	99	8.05	100	8.14	101
Lc-B	7.64	7.24	8.04	7.61	7.78	96.7	7.94	98.8	8.01	99.6	8.11	101

Acronyms: Hd (soil humidity), fH (variability of damping), Rc (soil acidity), Sl – total salt content in soil, Ca – calcium/magnesium content in soil, Nt – nitrogen content in soil, Ae – soil aeration, Tm – thermal climate, Om – ombroregime, Kn – continental climate, Cr – cryoclimate, Lc – light in the communities.

Table 4: Numbers of species and proportions in distinguished syntaxa by the Grime's CSR strategy.
Tabela 4: Število vrst in deleži v posameznih sintaksonih glede na CSR strategije po Grimu.

Syntaxon	C	S	R	Proportion C		S		R
Schivereckio podolicae-Seselietum libanotidis	9	5	1	1	:	0.6	:	0.2
Minuartio auctae-Festucetum pallentis	10	6	2	1	:	0.6	:	0.2
Transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea*	15	6	1	1	:	0.4	:	0.1
Average values	11.3	6	1	1	:	0.5	:	0.06

Based on the obtained indicators of species participation in specific communities (Table 4), we calculate the average values for associations and the proportions of their ratio, where the category of competitors (C) = 1.

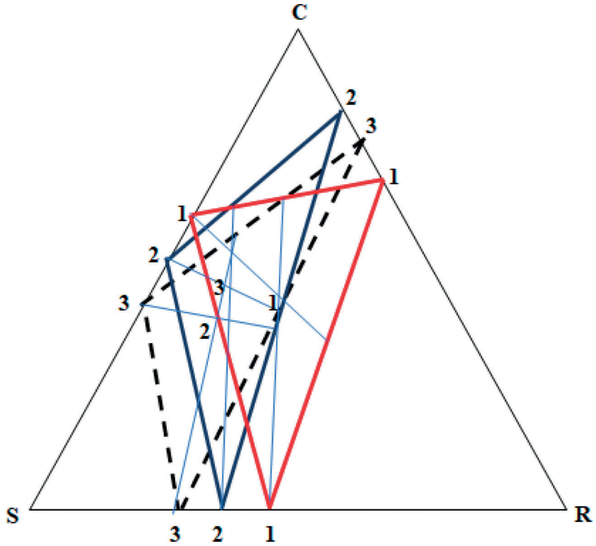

Figure 4: Distribution of species by proportions according to the indicators of Grime's CSR strategy (A) and the position of the "center of their masses" (B), which determines the patterns of development of the communities. 1-*Schivereckio podolicae-Seselietum libanotidis, 2-Minuartio auctae-Festucetum pallentis,* 3-transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea*.

Slika 4: Deleži vrst glede na CSR strategije po Grimu (A) in položaj njihovega »težišča«, ki opredeljuje vzorec razvoja teh združb. 1-*Schivereckio podolicae-Seselietum libanotidis, 2-Minuartio auctae-Festucetum pallentis,* 3- prehodna združba med razredoma *Festuco-Brometea* in *Trifolio-Geranietea.*

Discussion

Phytosociological peculiarities of communities with the presence of *Festuca pallens*

As we can see from Table 1, the communities are divided into three groups. The first and second groups reflect the communities of the *Festuco-Brometea* class, presented by the *Schivereckio podolicae-Seselietum libanotidis* and *Minuartio auctae-Festucetum pallentis* associations of the *Galio campanulati-Poion versicoloris* alliance, *Stipo pulcherrimae-Festucetalia pallentis* order. The third group reflects derivative stages of developing dry grassland communities, but we could not classify them and will refer to them as transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea*. According to the results we propose syntaxonomic scheme of the communities with the occurrence of *Festuca pallens*

Cl. *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947
- **Ord.** *Stipo pulcherrimae-Festucetalia pallentis* Pop 1968
  - **All.** *Galio campanulati-Poion versicoloris* Kukovitsa et al. 1994 ex Didukh & Vasheniak 2018
    - **Ass.** *Schivereckio podolicae-Seselietum libanotidis* Didukh & Vasheniak 2018
    - **Ass.** *Minuartio auctae-Festucetum pallentis* Onyshchenko 2001
    - **Com**. transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea*

The *Schivereckio podolicae-Seselietum libanotidis* association has already been known in the Western and Central Podillia (Didukh & Vasheniak, 2018), but without mention of *Festuca pallens*. According to our present results, these communities with this fescue species develop explicitly on Tortonian gypsum rocks exclusively in Opillia (geomorphological part of Western Podillia).

The *Minuartio auctae-Festucetum pallentis* association (Table S2) was described by Onyshchenko (2001) from Krements Ridge as part of the Medobory Nature Reserve within the *Alysso-Sedion* alliance, order *Alysso-Sedetalia*, class *Sedo-Scleranthetea*. We (Vasheniak et al., 2021), however, transferred it to the class *Festuco-Brometea* and it is now considered within the alliance *Galio campanulati-Poion versicoloris*, order *Stipo pulcherrimae-Festucetalia pallentis*, because perennial plants dominate (*Allium lusitanicum*, *Asperula cynanchica*, *Carex humilis*, *Elytrigia intermedia*, *Euphorbia cyparissias*, *Festuca pallens*, *Festuca stricta* subsp. *sulcata*, *Koeleria macrantha*, *Medicago falcata*, *Potentilla incana*, *Sedum acre*, and *Scabiosa ochroleuca*), although therophytes are present in with high frequency (*Arenaria serpyllifolia*, *Clinopodium* *acinos*, and *Saxifraga tridactylites*) and herbaceous layers with sparse cover. These communities occur mainly on Sarmatian limestones of the Volyn-Podillia Upland. The floristic composition of the third group is very diverse. Although most species belong to the *Festuco-Brometea* class, they are acutely disturbed and characterize the stages of colonization of carbonate deposits where erosiophiles are present (*Anthericum ramosum*, *Echium vulgare*, *Inula ensifolia*, *Salvia verticillata*, *Teucrium chamaedrys*, *T. montanum*, and *Vincetoxicum hirundinaria*), along with forest edge species (*Geranium sanguineum*, *Polygonatum odoratum*, *Vicia cracca*) and even shrubs (*Cytisus albus*, *C. paczoskii*, *Geranium sanguineum*, *Lembotropis nigricans*). It is obvious that there are two possibilities: closed steppe communities and derivative stages of their formation, in which *Festuca pallens* thrives in the absence of competition or with less competition. To confirm the violation of living conditions, the initial stages of community formation indicate the results of processing by the expert system HES (Janišová et al., 2007), where three relevés from the group were recognized as *Trifolio-Geranietea* class. On the other hand, the EuroVegChecklist Expert System (Mucina et al., 2016) shows that all relevés belong to the *Festuco-Brometea* class (Table S2). In our view, these communities lose distinct syntaxonomical affiliation and move to transitional communities, but they retain the floristic core of steppe species and can be classified within *Festucion valesiacae* alliance, order *Festucetalia valesiacae*, at this current stage.

Moreover, the core of the communities with the occurrence of *Festuca pallens* is considered as *Galio campanulati-Poion versicoloris* alliance, which according to Didukh et al. (2021) is vicarious to *Bromo pannonici-Fectucion csikhegyensis* alliance occurring in the Pannonian province (Svydovets Mountains in Ukraine). Moreover, the highest concentration of relevés from the second cluster was recognized as *Bromo pannonici-Fectucion csikhegyensis* alliance by the Slovak expert system HES (Janišová et al., 2007), confirming our previous point. Thus, these petrophytic communities are clearly different from the communities that occur in Central Europe (Didukh et al., 2021). It is noteworthy that communities with the presence of *Festuca pallens* are more widespread in Central Europe than in Eastern Europe within the *Bromo pannonici-Fectucion csikhegyensis* and *Diantho lumnitzeri-Seslerion albicantis* alliance. Although these alliances have been mentioned in Ukraine (Janišová et al., 2014; Didukh et al., 2021), this is probably due to the fact that the communities with *Festuca pallens* are located at the eastern limit of the range and belong to other alliances that differ in their environmental conditions from the communities within the optimum environment in Central or Southern Europe.

Ecological assessment of *Festuca pallens* habitats, threats to the existence of the species and forecast of possible changes

Most habitats of *Festuca pallens* are vulnerable and could change under the influence of various ecological factors. The communities of the *Minuartio auctae-Festucetum pallentis* and *Schivereckio podolicae-Seselietum libanotidis* associations grow on initial soils that developed on gypsum and limestone and are highly dependent on the chemical composition of the parent rock (Didukh & Vasheniak, 2018). Obviously, initial soils differ by their acidity, because *Schivereckio podolicae-Seselietum libanotidis* communities grow on gypsols with higher acidity than on epilithic soils where *Minuartio auctae-Festucetum pallentis* communities occur. It should be added that calcium carbonate on limestone rocks is easily converted to soluble forms of calcium bicarbonate that reduce acidity, which is not typical of gypsum formed from poorly soluble calcium sulfate. Moreover, according to our analysis, the communities of the association *Schivereckio podolicae-Seselietum libanotidis* occur in the southern part of the Volyn-Podillia Upland in the Velyki Goldy Ridge and Opillia and *Minuartio auctae-Festucetum pallentis* in the northern part of the Volyn-Podillia Upland in the Krements Ridge and Volyn Upland. This fact causes them to differ in cryoregime vectors (Figure 3).

On the other hand, the shaded transitional communities grow on more or less developed rendzic leptosols with a thickness of more than 5 cm, rich in organic matter and in which there are soluble forms of calcium bicarbonate and other anions. Not only herbaceous plants, but also shrubs (*Cytisus albus*, *C. paczoskii*) and young trees (*Pinus nigra*) can settle in such groups, indicating a successive change in the direction of afforestation of these particular grasslands. The next step of our analysis was to evaluate the threats to the existence of these communities. Since they belong to the E1.2 petrophytic type habitats (Perennial calcareous grasslands and basic steppes), they are not threatened by any anthropogenic impacts, except for possible mechanical destruction or overgrowth of shrubs (*Berberidion*) (Korotchenko, 2011). Nevertheless, the question of possible changes related to climatic factors is important. It is known that differentiation, function and development of communities are determined by hydrothermal conditions (temperature and precipitation). Based on the research of climatologists and the forecasts developed by them, an increase in average annual temperatures is observed, while changes in annual precipitation, both in the past and in the future, have a fluctuating character (Krakovskaia et al., 2009). Considering this fact, as well as the peculiarity of carbonate substrates, where precipitation is not delayed, the peculiarities of the groups adapted to the conditions of moisture deficiency, as well as the high resistance to environmental changes, we focused our calculations on the assessment of temperature changes. At the same time, we assumed that such climate changes act as a trigger mechanism that affects a change in edaphic properties of the soil, and such an indirect effect is much more significant than direct effects (Didukh et al., 2016). Based on the correlations between the changes in average annual temperatures, thermoregime of humidity of the climate, and continentality cryoregime, as well as indicators of edaphic factors (soil humidity and salt regime), corresponding calculations were carried out on the change of indicators at an increase in average annual temperatures by +1, +2, +2, 5, and +3 °C (Table 3) (Didukh, 2021). At an increase of +1 °C, the average thermoregime is already beyond the amplitude of the modern existence of these communities, and with changes in temperature conditions, these groups fall into the risk zone of reduction. They are also in such a zone at a temperature increase of +2 °C, and at an increase to +2.5 °C and +3 °C they fall into the risk zone of existence and are threatened with extinction. Accordingly, they fall into the risk zone of reduction in terms of cryoclimate indicators, when the temperature rises +2 and +3 °C, and the humidity of the climate and the acidity of the soil at +2, and losses - /+ 3 °C. The risk zone of reduction in relation to the change of salt regime is much broader and is established when the temperature rises above 2 and 3 °C. On the other hand, indicators of factors such factors as continentality, variability of damping, carbonate and nitrogen content, soil aeration with increasing temperature do not limit these communities.

In contrast to more closed communities formed on developed soils with stronger competition (forest, steppe, meadow), where the impact of climate change is indirect and manifested by changes in edaphic factors, the direct climate in this case shows a stronger impact of change, especially in terms of increasing temperatures and PAR (phytosynthetically active radiation) with the change in edaphic factors. To develop predictions of potential changes in these communities, we use the Grime species ecosystem indicators (CSR), which reflect ecosystem functioning, development, and sustainability based on assimilation, accumulation, and transfer of environmental resources, energy, conservation, and transmission of genetic information (Didukh et al., 2016).

As shown in Figure 4, all indicators in the CS zone are somewhat closer to C (competitors) than to S (stress tolerants) and very far from R (ruderal species). This could be due to the fact that their development is possible due to successional mechanisms, but limited by extremes. This is due to the carbonate substrate where resource use is limited and calcareous species are narrowly specialized (Didukh, 2011). It should be mentioned that the location of the *Schivereckio podolici-Seselietum libanotidis* and *Festuco-Brometea* to *Trifolio-Geranietea* transitional communities is closer to the apex C of the triangle than the location of the typical petrophytic communities of the *Minuartio auctae-Festucetum pallentis* association. The following specialization of calcareous stress-tolerant adaptive mechanisms, including the introduction of new species and successional changes, could determine the structure and development of these communities existing in extreme conditions.

Conclusions

Festuca pallens is distributed only in the Volyn-Podillia Upland in Ukraine and thrives on the eastern limit of its range. Populations of small sizes in isolated locations have been found on dry gypsum, limestone and chalk substrates. The communities in which *Festuca pallens* occurs used to belong to the associations *Schivereckio podolicae-Seselietum libanotidis* and *Minuartio auctae-Festucetum pallentis*, to the alliance *Galio campanulati-Poion versicoloris*, to the order *Stipo pulcherrimae-Festucetalia pallentis* and to communities in derivative stages of development of steppe vegetation. These communities are ecologically distinct from those found in Central and Southern Europe. According to the method of synphytoindication, the environmental conditions of the communities were presented and it was also calculated that in the case of a + 2 °C increase in the average annual temperature, a change in the living conditions is possible, which will lead to a decrease in the population of the area, and in the case of a +3 °C increase, to its loss. Successive changes in these communities were limited by extreme conditions caused by carbonate substrates that limit resource use. *Festuca pallens* is a rare species in Ukraine and is listed in the Red Data Book of Ukraine, and the communities where *Festuca pallens* occurs are listed in the Green Data Book of Ukraine. In addition, the habitats are listed in Resolution 4 of the Bern Convention as E1.2 Perennial calcareous grasslands and basic steppes and in Annex I of the Habitat Directive 92/43 as 6190 Rupicolous pannonic grasslands (*Stipo-Festucetalia pallentis*) and need to be protected. In our opinion, management measures should include further steps: the introduction of sustainable grazing by cows, goats and horses on *Festuca pallens* habitats; the implementation of an information campaign against spring burning; the removal and control of invasive plants in the habitats; the prevention of inappropriate afforestation of steppe slopes; the fight against illegal mining of limestone and gypsum on *Festuca pallens* habitats.

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Appendix

List of localities of *Festuca pallens* Host according to herbarium funds (asterisk indicates the localities where the current growth of the *Festuca pallens* is not confirmed).

Ternopil region, Krements Ridge: Bozha hill* (s. coll. 1858 LE; Rogovych 1898 LE; Zapiatova 1961 KW, s. coll. 1961 KW; Bednarska 2005 LWKS IB-896), Divochi Skeli tract (Divocha hill) (Mądalski 1936 LWS 32733; Gryn 1940 KW; Kotov, Temko 1954 LE; Klokov, Zaverukha 1958 KW; Prokudin, Shustova 1958 CWU; Lazebna 1976 LWS 32734, 32735, 32736; Kagalo 1983 LW 011664; Kagalo 1984 LW; Kagalo, Gynda 1988 LWKS 01630; Kagalo, Bednarska 1998 LWKS 8492; Bednarska 2005 LWKS IB-893), Chercha hill (Mryts 1936 LWS 32948; Zapiatova 1961 KW), vicinity of Zholoby and Pidlistsi villages, Strakhova hill (Gryn 1940 KW; Iermachenko 1958 CWU; Klokov, Zaverukha 1958 KW; Zaverukha 1959 KW 009190, 005497, 005498; Zaverukha 1959 LWKS 201; Prokudin, Tveretynova 1964 LE; Bednarska 2005 LWKS IB-901), vicinity of Krements town (Rogovicz, 1952 LE; Barbarych, Kucheriava 1958 KW; s. coll. 1893 LE), vicinity of Kulykiv village, Lysa hill (Bednarska 2005 LWKS IB-1593; Kagalo, Skibitska, Resler 2006 LWKS 25205; Bednarska, Kagalo 2007 LWKS IB-1167, IB-1168), vicinity of Mykolayiv village, Lysa hill (Klymyshyn 1987 LWS 18439, 18440), Pidvolochysk district, Ostapie village* (Wołoszczak 1889 LW 012060:"Ostapie, in montibus Miodobory. Exempl. cultur Leopoli"; Błocki s. dat. LWS 10.507), Shumsk district, Tsetsenivka village* (s. coll. 1958 KW).

Ivano-Frankivsk region, Galych district: Mezhygirtsi village [single plants in semi-degraded habitat] (Kuziarin 2000 LWS), Podillia village (Zaverukha 1976 KW 1 sheet without number + sheet № 005835; Kagalo, Bednarska 1998 LWKS 8896; Bednarska, Nakonechyi 2000 LWKS IB-181, 11598; Kagalo, Bednarska 2014 LWKS IB-1677); Rogatyn district: Luchyntsi village, Velyki Goldy tract (Shevchuk 1961 LWS 10.566; Lazebna 1978 LWS 32740, 32741; Kagalo 1988 LWKS 020546; Kagalo, Bednarska 1998 LWKS 8489; Bednarska, Nakonechyi 2000 LWKS IB-191).

Rivne region, Dubno district: Mylcha village (Didukh 2000 KW 008689; Bednarska, Kagalo 2007 LWKS IB-1173c).

Table 2: Phytosociological table of the communities with the presence of *Festuca pallens*. Species are arranged according to decreasing phi-values and according to decreasing overall constancy for non-diagnostic species.

Tabela 2: Fitocenološka tabela združb z vrsto *Festuca pallens*. Vrste so razvrščnene padajoče glede na fi vrednost, neznačilne vrste pa padajoče glede na skupno stalnost.

Table number	33	34	32	45	46	35	28	43	44	42	29	30	31	23	26	27	24	25	18	21	19	22
Releve number (TURBOVEG)	70	71	69	204	208	72	65	202	203	201	66	67	68	60	63	64	61	62	55	58	56	59
Country code	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA
Nr. table in publ.	16158	16159	16157			16161	16149				16153	16154	16155	7021	7040	7048	7035	7037				
Nr. relevé in table	1	1	1			1	1				1	1	1	1	1	1	1	1	56	61	59	62
Cover abundance scale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Date (year/month/day)	20160806	20160806	20160806	20160806	20160806	20160806	20160805	20160806	20160806	20160806	20160805	20160805	201608	20070502	20070620	20070620	20070620	20070620	20180628	20180628	20180628	20180628
Relevé area (m2)	16	16	16	10	10	16	16	10	10	10	16	16	16	16	16	16	16	16	10	10	10	10
Altitude (m)	200	200	205	299	342	340	265	237	277	273	270	278	314	290	205	205	200	200	371	391	387	376
Aspect (degrees)	350	350	180		40	205	270	340	310	330	180	270	270	180	270	230	180	180	260	298	40	140
Slope (degrees)	90	90	80			40	90				60	60	45	30	30	5	15	10	75	75	10	15
Cover total (%)	70	50	40	60	60	40	40	60	60	60	30	50	50	30	30	30	40	30	80	50	80	80
Cover shrub layer (%)																			5		5	
Cover herb layer (%)	70	70	40	40	50	70	40	45	40	40	30	15	40	30	30	30	40	30	60	20	60	30
Cover moss layer (%)	20	20	20	20	10	20	5	15	20	20		40	20						20	30	20	50
Cover litter layer (%)	2	2	10			30	10				10	10	10	10	10	10	10	10				
Cover bare rock (%)	50	50	50			20	60				70	70	50	70	80	80	70	80				
Aver. height (high) herbs (cm)	100	100	80			80	100				50	100	80	15	15	15	15	15				
Aver. height lowest herbs (cm)	10	10	20	1	3	30	20	2	2	1	30	20	20	15	10	10	15	10				
Maximum height herbs (cm)				54	80			50	99	30									58	51	67	25
Mosses identified (y/n)				Y	Y			Y	Y	Y									Y	Y	Y	Y
Lichens identified (y/n)				Y	Y			Y	Y	Y									Y	Y	Y	Y
longitude	24.736	24.736	24.736	24.742	24.484	24.770	24.652	24.740	24.740	24.740	24.669	24.669	24.670	24.442	25.724	25.724	25.634	25.725	50.094	50.095	50.094	50.094
latitude	49.276	49.276	49.276	49.276	49.118	49.120	49.338	49.277	49.277	49.277	49.284	49.284	49.284	49.405	50.118	50.118	50.056	50.117	25.740	25.732	25.733	25.733
HES	FBB01?	FBB01?	FBB01?	FBB01?	TGA01?	TGA01?	FBB01?	FBB01?	FBB05?	FBB05?	FBB05?	FBB05?	FBC02?	FBA02?	FBA02?	FBA02?	FBA02?	FBB05?	FBB04?	FBB01?	FBB01?	FBB01?
EuroVegChecklist	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	SED	SED	FES	FES
Releve ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

Table number	17	16	6	10	5	8	4	7	1	2	3	41	15	11	12	14	9	36	38	40	39	37
Releve number (TURBOVEG)	54	53	43	47	42	45	41	44	38	39	40	200	52	48	49	51	46	97	99	101	100	98
Country code	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA	UA
Nr. table in publ.																						
Nr. relevé in table	58	57	46	50	45	48	44	47	41	42	43		55	51	52	54	49	100	103	105	104	101
Cover abundance scale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Date (year/month/day)	20180628	20180628	20180606	20180627	20180606	20180606	20180606	20180606	20180606	20180606	20180606	20160806	20180627	20180627	20180627	20180627	20180606	20200813	20200813	20200813	20200813	20200813
Relevé area (m2)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Altitude (m)	374	368	371	381	367	379	375	363	373	372	375	230	370	391	377	378	373	214	235	212	234	231
Aspect (degrees)	130	160	270	280	230	210	240	240	240	70	200	220	200	220	170	200	280	275	170	210	250	229
Slope (degrees)	20	35	5	70	5	5	3	27	5	5	3	5	30	15	25	30	15	21	15	10	11	20
Cover total (%)	80	80	70	80	80	80	90	80	90	90	90	80	80	80	80	80	80	30	60	60	60	60
Cover shrub layer (%)	5	5											5									
Cover herb layer (%)	60	60	50	60	60	50	85	60	70	70	60	60	60	50	75	60	70	20	40	50	55	55
Cover moss layer (%)	20	20	20	10	20	30	5	20	20	20	30	20	20	20	5	20	10	10	20	10	5	5
Cover litter layer (%)																						
Cover bare rock (%)																						
Aver. height (high) herbs (cm)																						
Aver. height lowest herbs (cm)												1										
Maximum height herbs (cm)	53	53	50	50	20	50	25	50	81	85	50	50	80	80	80	50	80	35	39	108	81	61
Mosses identified (y/n)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
Lichens identified (y/n)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
longitude	50.094	50.093	50.119	50.074	50.118	50.117	50.118	50.118	50.117	50.118	50.118	24.670	50.085	50.080	50.079	50.085	50.080	25.566	25.567	25.567	25.566	25.566
latitude	25.734	25.737	25.727	25.644	25.727	25.729	25.727	25.728	25.730	25.729	25.729	49.284	25.674	25.645	25.645	25.674	25.644	50.354	50.355	50.356	50.355	50.354
HES	FBB01?	FBB04?	FBB01?	FBB05?	FBC02?	FBB05?	FBB02?	FBB04?	FBC01?	FBC01?	FBC02?	TGA01?	TGA01?	TGA01?	TGA01?	FBB05?	FBC02?	TGA04?	FBB01?	FBB05?	FBB02?	FBB05?
EuroVegChecklist	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES	FES
Releve ID	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44

Table number	33	34	32	45	46	35	28	43	44	42	29	30	31	23	26	27	24	25	18	21	19	22	17	16	6	10	5	8	4	7	1	2	3	41	15	11	12	14	9	36	38	40	39	37
Releve number (TURBOVEG)	70	71	69	204	208	72	65	202	203	201	66	67	68	60	63	64	61	62	55	58	56	59	54	53	43	47	42	45	41	44	38	39	40	200	52	48	49	51	46	97	99	101	100	98
Festuca pallens	r	+	r	r	r	r	2	2	2	1	2	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2	2	r	r	2	2	r	2	r	2	2	2	2	r	2	2	3	r	r
Ass. *Schivereckio podolicae-Seselietum libanotidis*																																												
Gypsophila thyraica	.	.	2	.	+	1	2	2	2	r	2	1	2	1	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	r	.	.	2	r	.	.	.	.	2
Thymus pannonicus	.	.	.	.	.	.	.	r	+	r	r	r	.	r	r	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.
Campanula rotundifolia	+	1	.	r	.	.	.	r	r	r	.	.	.	r	.	.	r	r	.	2	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus onobrychis	.	.	r	.	r	+	.	.	r	.	r	r	.	.	.	r	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Arabidopsis arenosa	r	.	.	r	r	r	+	r	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r
Ass. *Minuartio auctae-Festucetum pallentis*																																												
Clinopodium acinos	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	r	r	r	r	.	.	r	r	2	r	.	r	r	r	.	.	.	.	.	.	.	.	.	.	r
Thymus serpyllum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	r	r	.	.	3	.	r	+	+	r	r	.	r	.	.	.	.	r	.	.	.	r	.	.
Alyssum gmelinii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	r	.	r	r	r	.	.	.	r	+	.	.	.	.	.	r	.	.	.	.	.
Minuartia setacea subsp. *setacea*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	r	+	r	2	.	2	.	.	r	r	2	r	.	2	.	r	.	.	r	.	.	.	.	.	.
Medicago falcata	.	.	.	.	+	+	.	.	r	.	.	.	.	.	.	.	+	.	r	.	.	r	.	r	r	r	.	r	r	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.
Centaurea stoebe	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	.	.	r	r	.	.	r	.	r	.	r	.	.	r	.	.	.	.	.	.
Anthyllis vulneraria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	r	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga tridactylites	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	+	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Silene eugeniae	.	.	1	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
transitional communities from *Festuco-Brometea* to *Trifolio-Geranietea*																																												
Anthericum ramosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	+	.	+	.	.	+	2	2	2	2	2	.	.	2	2	2
Teucrium chamaedrys	.	.	.	.	.	.	.	.	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	r	r	r	r	r	r	.	.
Stipa capillata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	r	r	r	r	r	.	.	.	.	.
Salvia verticillata	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	r	+	r
Geranium sanguineum	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	r	.	.	.	.	.	.
Cytisus paczoskii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	2	.	.	.	.	.
Galium boreale subsp. *exoletum*	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	r	+	r
Teucrium montanum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	r	.	.	2	+	.	r	.	2	.	2	.
Thalictrum minus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	r	.	r	r	.	.	.	.	r
Galium mollugo	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	r	.
Pimpinella saxifraga	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	r	r
Stachys recta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	r	.	r	r
Cytisus albus	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	2	.	.	.	.	.
Lembotropis nigricans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	r	.	.	.	.	.	.
All. *Galio campanulati-Poion versicoloris*, Ord. *Stipo pulcherrimae-Festucetalia pallentis*, Cl. *Festuco-Brometea*																																												
Potentilla incana	.	.	.	.	1	1	.	.	r	.	.	+	.	r	r	.	.	r	.	.	r	.	r	2	.	.	r	2	2	2	2	2	r	.	2	2	r	r	.	r	.	+	+	+
Allium lusitanicum	.	+	+	.	1	1	1	r	r	r	2	2	2	.	.	.	.	+	.	.	.	.	.	.	2	2	r	2	.	2	2	2	2	r	.	r	r	.	.	.	.	.	.	.
Sedum acre	1	+	.	.	.	.	.	.	.	.	r	r	3	+	+	+	+	.	2	+	+	2	+	.	+	r	.	r	r	2	+	r	.	.	.	.	.	.	.	.	2	.	.	.
Helianthemum canum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	r	.	r	.	r	r	.	.	r	.	r	r	r	2	2	.	.	2	r	r

Table number	33	34	32	45	46	35	28	43	44	42	29	30	31	23	26	27	24	25	18	21	19	22	17	16	6	10	5	8	4	7	1	2	3	41	15	11	12	14	9	36	38	40	39	37
Releve number (TURBOVEG)	70	71	69	204	208	72	65	202	203	201	66	67	68	60	63	64	61	62	55	58	56	59	54	53	43	47	42	45	41	44	38	39	40	200	52	48	49	51	46	97	99	101	100	98
Carex humilis	.	.	.	.	.	.	.	.	2	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	2	2	2	.	.	.	r	2	2	+	.	2	2	.	.	.	2	r
Melampyrum arvense	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	r	r	r	r	.	.	.	.	.	.	.	.	.	.
Inula ensifolia	.	.	.	.	.	.	.	.	.	.	+	r	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	r	r	.	.	.	.	.	.	.
Galium glaucum	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	r	.	.	.	.	.	.	.
Iris aphylla subsp. *hungarica*	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.
Sempervivum ruthenicum	2	3	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Festuco-Brometea																																												
Asperula cynanchica	r	.	.	.	r	r	.	r	r	.	r	r	r	.	1	.	+	r	.	.	.	.	r	r	.	r	r	.	+	.	.	r	.	r	r	r	.	r	r	.	.	.	.	r
Artemisia campestris	.	+	2	.	2	2	1	.	.	.	+	.	r	.	r	r	+	.	r	r	r	r	.	r	.	.	r	r	r	.	r	r	.	+	.	.	.	.	.	.	.	.	.	.
Festuca stricta subsp. *sulcata*	2	2	.	r	r	r	.	.	r	r	.	.	.	.	.	.	.	.	.	.	2	r	.	r	2	.	.	r	.	.	r	r	.	.	.	.	.	.	.	.	r	.	.	.
Campanula sibirica	.	.	.	.	.	.	.	.	.	r	r	r	r	.	.	.	.	r	2	.	.	.	.	.	.	r	.	.	.	r	.	r	.	.	.	.	.	r	r	.	.	r	.	r
Elytrigia intermedia	r	.	.	.	+	1	+	r	.	.	.	.	.	.	.	.	.	.	r	.	.	r	r	r	r	r	.	.	.	.	.	.	.	.	r	r	.	.	.	.	r	.	r	.
Euphorbia cyparissias	.	.	.	.	r	r	1	r	r	r	1	+	+	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	r	r	.	r	r	.	r	.	.	r	r	r	r	r
Arenaria serpyllifolia	2	1	.	r	r	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Scabiosa ochroleuca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	r	.	.	r	.	r	r	r	r	r	r	.	r	.	.	r	r	.	r	.	r	r
Koeleria macrantha	.	.	.	.	+	+	1	r	r	r	.	.	.	.	.	.	r	.	.	.	r	r	.	.	r	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	+	r	.	r
Hypericum perforatum	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	r	r	.	r	.
Euphorbia seguieriana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	2	2	.	r	.	.	.
Other species																																												
Veronica spicata	.	.	.	.	r	r	+	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	r	.	r	r	.	.	.	.	.	.	.	.	.
Asplenium ruta-muraria	.	r	.	r	.	.	.	.	r	.	.	.	.	.	.	r	.	+	r	r	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium verum	.	.	.	.	r	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	r	.	2
Echium vulgare	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	r	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	r	.
Vincetoxicum hirundinaria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	r	r	.	r	.	.	.	.	.
Centaurea phrygia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r
Hieracium umbellatum	.	.	.	.	r	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium robertianum	r	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peucedanum cervaria	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Seseli libanotis subsp. *intermedium*	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Cryptogam species (in alphabetical order)																																												
Abietinella abietina	.	.	.	2	2	.	.	r	r	.	.	.	.	.	.	.	.	.	.	r	2	.	.	.	r	2	2	r	.	2	2	2	2	.	.	.	.	.	.	.	2	2	+	.
Barbula unguiculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	+	1	2	.	r	.	.	.	.	.	.	2	.	.	.	.	.
Brachythecium albicans	.	.	.	2	.	.	.	r	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bryum argenteum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.	r	.	r	.	.	.	r	.	.	.	.	.	.
Bryum kunzei	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	2	2	2	.	r	.	2	2	2	.	.	2	.	.	.	2	+	.	.	.	.	.	.
Ceratodon purpureus	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	2	2	.	r	r	.	+	2	.	2	+	.	.	+	.	.	.	.	.	.	.	.	.	.
Cladonia pocillum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	2	r	.	.	.	.	.	r	.	.	.	.	.	.	.

Table number	33	34	32	45	46	35	28	43	44	42	29	30	31	23	26	27	24	25	18	21	19	22	17	16	6	10	5	8	4	7	1	2	3	41	15	11	12	14	9	36	38	40	39	37
Releve number (TURBOVEG)	70	71	69	204	208	72	65	202	203	201	66	67	68	60	63	64	61	62	55	58	56	59	54	53	43	47	42	45	41	44	38	39	40	200	52	48	49	51	46	97	99	101	100	98
Cladonia pyxidata	.	.	.	.	.	.	.	2	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.
Collema tenax	.	.	.	.	.	.	.	1	2	2	.	.	.	.	.	.	.	.	2	.	.	.	.	.	r	.	.	.	.	2	.	r	.	r	.	.	.	.	.	.	.	.	.	.
Ditrichum flexicaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	.	.	.	2	2	2	r	2	.	r	.	.	.	2	2	.	+	.	.	.	.	.
Encalypta vulgaris	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	2	.	2	2	2	2	.	2	.	.	.	.	.	r	.	.	.	.	2	.	.	.	.	.	.	.
Homalothecium lutescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	r	.	.	.	.
Homalothecium sericeum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	2	.	.	.	.	.	.	.	.	2	r	2	.	.	2	.	.	.	.	.	.	.	.
Hypnum vaucheri	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	+	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudocrossidium hornschuchianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Rhytidium rugosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	2	2	.	.	.	.	.	.	.	.	.	.	.
Tortella tortuosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.	.	.	2	.	.	2	.	.	r	.	.
Tortula calcicolens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	2	2	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Tortella inclinata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	2	2	.	.	2	.	.	.	2	2	2	.	.	.	.	.
Tortula ruralis	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	2	.	.	.	2	2	.	.	2	2	3	.	.	.	.	2	.	.	2	.	.	.
Weissia sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	.	.	.	r	.

Species of vascular plants, rarely occurred in the communities:

Acer negundo (40:r), *Achillea millefolium* (34:r), *Adonis vernalis* (34:r), *Allium podolicum* (5-6:r; 32:r), *A. strictum* (18:r), *Alyssum hirsutum* (17:r), *A. rostratum* (29-31:r), *Asplenium trichomanes* (15:r; 31:r), *Astragalus austriacus* (25:r), *Aurinia* sp. (15:+; 16:r; 18:r), *Berberis vulgaris* (38:r; 44:r), *Berteroa incana* (19:+; 28:r), *Betula klokovii* (39:r), *Botriochloa ischaemum* (17:r), *Brachypodium pinnatum* (4:r), *Bromus squarrosus* (22:r), *Bupleurum falcatum* (34:r), *Carex hirta* (17:r), *Carlina acanthifolia* subsp. *utzka* (39:r), *Centaurea jacea* (40:r), *C. scabiosa* (35:r), *Cerastium arvense* (2:r; 14:r; 24:r; 41:r), *Convolvulus arvensis* (43:r), *Cornus sanguinea* (42:r), *Cytisus blockianus* (8-9:r), *C. ruthenicus* (27:r; 31:r; 32:r), *Daucus carota* (40:r), *Dianthus arenarius* subsp. *pseudoserotinus* (28:r; 32:r), *Dictamnus albus* (35:r), *Draba verna* (20:r), *Epipactis atrorubens* (38:r), *Erysimum diffusum* (2:r; 3:r; 13:r), *Euphorbia nicaeensis* subsp. *stepposa* (26:r; 27:r; 29:r), *E. stricta* (8:r), *Fragaria viridis* (40:r), *Frangula alnus* (35:r; 39:r), *Galium humifusum* (19:r; 24:r), *Helianthemum nummularium* (31:r), *Helictotrichon desertorum* (18:+), *Holosteum umbellatum* (19:r), *Hylotelephium maximum* (1:2; 2:r; 7:r), *Hypericum elegans* (34:r), *Jacobaea vulgaris* (5-6:r; 34:r), *Jurinea mollis* (36:r; 39:r), *Lappula squarrosa* (22:r), *Linaria vulgaris* (41:r), *Linum catharticum* (37:r), *Lotus corniculatus* (40:r; 42:r), *Medicago minima* (19:r; 44:r), *Melampyrum cristatum* (11-13:r), *Melilotus albus* (1:r), *M. officinalis* (32:r), *Noccaea perfoliata* (19:r), *Onobrychis arenaria* (41:r; 44:r), *Otites* sp. (17:+), *Peucedanum oreoselinum* (37:r), *Pilosella officinarum* (41:r; 44:r), *Pinus nigra* (juv.) (27:r; 39:r), *Poa compressa* (8:r; 22:r; 40:r), *Polygala comosa* (42:r), *Polygonatum multiflorum* (26:r; 35:r; 37:r; 38:r), *Polygonatum odoratum* (5:+; 6:+), *Prunella grandiflora* (37:r), *Rhinanthus minor* (5-6:+), *Rosa tomentosa* (5:r), *Rubus caesius* (34:r), *Salvia nutans* (39:r), *S. pratensis* (34:r; 44:r), *Sedum hispanicum* (2:r; 3:r; 14:+), *Solidago canadensis* (42:r), *Stipa pulcherrima* (35:r; 37:r), *Thesium linophyllon* (32:r; 39:r), *Tragopogon dubius* (26:r), *Trinia multicaulis* (39:r), *Urtica dioica* (4:r), *Valeriana tuberosa* (26:r), *Verbascum phlomoides* (23:r; 24:r), *Veronica prostrata* (24:r), *Vicia cracca* (5:r; 6:+), *Viola canina* (43:r)

Cryptogam species, rarely occurred in the communities:

Bryum caespiticium (32:r), *Bryum* sp. (10:r), *Camptothecium lutescens* (5:1), *Campylium chrysophyllum* (22:r; 37:2), *Candelariella vitellina* (9:2), *Cladonia rei* (28:r), *Cladonia* sp. (19-20:r), *C. subulata* (8:r), *Collema crispum* (20:r), *Ctenidium molluscum* (40:+; 44:+), *Dicranella heteromalla* (22:2), *Dicranum bonjeanii* (10:2), *Didymodon fallax* (22:r; 27:r), *D. vinealis* (22:r; 27:r), *Diploschistes muscorum* (20:r), *Encalypta streptocarpa* (26:2), *Evernia mesomorpha* (4:r; 8:r), *Fissidens taxifolius* (37:2), *Grimmia pulvinata* (19:2), *Grimmia* sp. (28:r), *Gymnostomum calcareum* (26:2), *Hypnum cupressiforme* (21:r; 26:r), *Lecanora muralis* (25:r; 27:2), *Lepraria membranacea* (22:r), *Leptogium tenuissimum* (32:+), *Leskea polycarpa* (31:2), *Myurella julacea* (26:2), *M. sibirica* (26:r), *Orthotrichum affine* (5:+), *O. cupulatum* (27:2; 37:2), *Orthotrichum* sp. (31:2), *Peltigera malacea* (4:+), *P. rufescens* (33:r), *Physcia tenella* (4:+), *Ramalina pollinaria* (4:2; 8:+; 9:r; 10:r), *R. polymorpha* (4:+; 8:+; 9:2: 10:+), *Schistidium apocarpum* (33:r), *Schistidium* sp. (20:+; 31:r), *Toninia sedifolia* (21:r), *Tortula muralis* (19-20:r)

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