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Classification of semi-natural mesic grasslands in the Ukrainian Carpathians

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Abstract

Aims and study area: We present the first formalised large-scale syntaxonomic overview of mesic semi-natural grassland communities (*Arrhenatheretalia elatioris* and *Nardetalia strictae*) in the Ukrainian part of the Eastern Carpathians and adjacent areas of Hungary, Slovakia and Poland. Methods: During 2009–2014 we recorded 759 phytosociological relevés using the Braun-Blanquet approach. The classification was based on our own phytosociological material as well as published material recorded by both Braun-Blanquet and eco-phytocenotic (dominant) approach comprising 2,000 phytocoenological relevés in total (952 relevés in the stratified data set). Semi-supervised and supervised classifications by the K-means method and indirect gradient analysis by detrended correspondence analysis were used for the analyses. Slovak electronic expert system and diagnostic species for grassland vegetation published in national overviews in the neighbouring countries helped us to identify individual clusters. Didukh indicator values were used to compare habitat conditions of delimited plant communites. Results: A total of fifteen well-differentiated associations within five alliances and two classes were delimited: Class *Molinio-Arrhenatheretea* including the alliance *Arrhenatherion elatioris* with associations *Anthoxantho odorati-Agrostietum tenuis*, *Betonico officinalis-Trifolietum pannonici*, *Poo-Trisetetum flavescentis*, *Primulo veris-Agrostietum capillaris* and *Pastinaco sativae-Arrhenatheretum elatioris* and the alliance *Cynosurion cristati* with associations *Plantagini-Lolietum perennis* and *Lolio perennis-Cynosuretum cristati*. Class *Nardetea strictae* including the alliance *Nardo strictae-Agrostion tenuis* with associations *Antennario dioicae-Nardetum strictae*, *Campanulo abietinae-Nardetum strictae* and *Betonico officinalis-Agrostietum capillaris*, the alliance *Violion caninae* with associations *Campanulo rotundifoliae-Dianthetum deltoidis*, *Hyperico maculati-Deschampsietum flexuosae*, *Festuco rupicolae-Nardetum strictae* and *Polygalo vulgaris-Nardetum strictae caricetosum fuscae* and the alliance *Potentillo ternatae-Nardion strictae* with association *Soldanello hungaricae-Nardetum strictae*. The ecological differentiation of syntaxa is mainly based on certain environmental factors reflected in Didukh indicator values (DIV), management practices and altitude. Conclusions: This study complements current knowledge about mesic grasslands from poorly sampled area using the Braun-Blanquet approach. The classified syntaxa of mesic grasslands are discussed with respect to their distribution in the Carpathians and Europe and we expect that the results of our research will assist in the anticipated future supranational classification of mesic grasslands in the Carpathians.

Keywords: *Arrhenatherion elatioris*; *Cynosurion cristati*, meadow; *Nardo strictae-Agrostion tenuis*; pasture; semi-supervised classification; syntaxonomic revision; Ukrainian Carpathians; *Violion caninae*; supranational classification

Nomenclature: The taxonomic nomenclature for vascular plants follows the Euro+Med Plant Database (Euro+Med 2015). The names of missing taxa are in accordance with Flora Europaea (Tutin et al. 1968–1993). The nomenclature of mosses and lichens follows Marhold & Hindák (1998). Narrowly defined species or subspecies unified into a broader concept are listed in Supplement S1. The syntaxonomic nomenclature is unified according to Hegedüšová Vantarová & Škodová (2014). For syntaxa missing in the cited source, the full names with author abbreviations and year of publication are given.

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Introduction

Semi-natural grasslands in the temperate zone form a typical landscape structure with high species diversity on relatively small plots (Pärtel et al. 1996). They also provide the best life conditions for many species of endangered plants and animals (Šefferová Stanová & Plassman Čierna 2011). The existence of this vegetation is conditioned by climatic (e.g. light, temperature, moisture) and edaphic factors (e.g. geological bedrock, type of soil) as well as by regular human management of varying intensity. These habitats developed over centuries or even millennia of traditional land use such as mowing, grazing, temporary abandonment of arable fields and other disturbance regimes (Poschlod 2015). Both agricultural intensification and abandonment of traditional management caused dramatic losses in area and quality of European grassland habitats during recent decades (Veen et al. 2009), but in the Ukrainian Carpathians grasslands have been maintained in their typical form in a mosaic of pastures, small fields, meadows and fallows up to now (Kuemmerle et al. 2006, Škodová et al. 2015). However, the negative trends of grassland abandonment are also expanding gradually into this area. After liquidation of collective farms (kolkhozes) owned by the State in 1991 (Lerman et al. 2004), inhabitants returned to the traditional forms of management, but primarily on polonines (grasslands on the artificially deforested mountain ridges) large areas of arable land have been abandoned during the last 20 years (Kricsfalusy 2013). The conservation of high natural value grasslands in general became a priority throughout European Union as indicated in Annex I of Directive 92/43/EEC (European Commission 2013). To assess the conservation value of these communities, a consistent classification system with clearly defined vegetation units and their diagnostic species is needed (Dengler et al. 2013, Rodríguez-Rojo et al. 2014).

Phytosociological research according to the Braun-Blanquet approach has a long-term tradition since the beginning of the 20th century (Braun-Blanquet 1921). The semi-natural grasslands in the Carpathians belong to one of the first habitat types sampled by these methods (e.g. Szafer et al. 1923, 1927, Klika 1929). The vegetation research of grasslands in the Ukrainian Carpathians was performed over four main periods: Austro-Hungarian (1796-1918), Czechoslovakian (1918-1945), Soviet Union (1945-1991) and the present (from 1991). The first vegetation study from the Transcarpathians (especially from the valley of the Tisa River) was published by Kitaibel (1863). The primary aim of vegetation research in the Ukrainian and Polish Carpathians in the 20th century was not the classification of vegetation, but the impact of management on the vegetation (e.g. Swederski & Szafran 1931, Pawłowski 1937, Pawłowski & Walas 1949). Nevertheless, the grasslands of the Ukrainian Carpathians have not been studied systematically and the knowledge about their vegetation is still too general and scarce (Tasenkevich 2009). The available data on grassland diversity and distribution are far from complete and the existing information is often out of date (e.g. Malynovski 1959, Afanasiev 1968). The syntaxonomic system in Ukraine was traditionally based on the Russian phytosociological school (Alekhin 1951, Rabotnov 1983) according the dominant scale methods and approaches (Moravec et al. 1994). At that time, the Braun-Blanquet approach was used only sporadically (e.g. Mirkin 1987, Solodkova et al., 1986, Korotkov et al. 1991). The phytosociological research has so far developed in relative isolation from other parts of Europe due to limited access to relevant literature in both directions and linguistic constraints. This has led to many inconsistencies towards recent plot-based classifications elsewhere (Kuzemko et al. 2014). Phytosociological relevés published mainly in older studies from the last century were often recorded unsystematically, within heterogeneous plots, or with unknown or extremely large plot sizes (400 m^2 or more). This makes the comparison of old and newly-obtained data difficult. Recent studies of changes in the distribution of natural and semi-natural grasslands after collapse of the Soviet Union are not documented sufficiently (Tasenkevich 2009). The first comparison of data based on the dominance approach used in the Ukrainian Carpathians with classification of grasslands from adjacent countries with Braun-Blanquet methods (Poland, Slovakia, Romania) was published on high-altitude grasslands by Malynovski & Kricsfalusy (2002). Finally, several local studies of grassland vegetation from the lowland to the montane belts (Zarzycki 2002, Solomakha et al. 2004, Kuzemko 2009, Chorney et al. 2005, Klimuk et al. 2006, Milkina & Lyakh 2008a, Tokaryuk et al. 2009, Derzhypilsky et al. 2011, Kuzemko et al. 2014, Roleček et al. 2014, Škodová et al. 2015) and from the subalpine to the alpine belts (Tasenkevich 2009, Yakushenko et al. 2012, Kricsfalusy 2013) were published following the Braun-Blanquet approach. The phytosociological research of vegetation in Ukraine was summarized by Solomakha (2008), who included all published syntaxa, but without critical evaluation and synthesis. Altogether, 6 alliances with 23 associations of mesic grasslands were listed in that study with unclear floristic and ecological differentiation, containing only some diagnostic species and short comments for most of the included syntaxa.

Supervised classification is based on expert knowledge, included in formal definitions and computerised expert system, which help to ensure unequivocal rules for identification of syntaxa. By contrast, unsupervised methods can reveal the diversity of vegetation based on similarities in species composition or the main vegetation gradients (Rozbrojová et al. 2010). It is apparent that these two approaches are complementary (Roleček 2007). The demand for identifying new vegetation types not yet covered by supervised classification resulted in development

of new methods including the semi-supervised classification (De Cáceres et al. 2010, Tichý et al. 2014). The semi-supervised K-means algorithm uses a priori information about group membership for some sites to define centroids of clusters representing previously established vegetation units (Rodríguez-Rojo et al. 2014). In our study, we used the expert system for identifying grassland syntaxa of Slovakia (Janišová et al. 2007, Hegedüšová Vantarová & Škodová 2014) to build up a revised classification system of mesic grasslands in the Ukrainian part of the Carpathians adjacent to the Slovak territory. It is the first syntaxonomic revision of the semi-natural grassland vegetation in the Ukrainian Carpathians based on phytosociological relevés.

The aims of this study are: i) to classify the mesic grassland vegetation in the Ukrainian Carpathians using formalized supervised and semi-supervised methods; ii) to compare the resulting classification with the classification systems used in the neighbouring Carpathian countries; iii) to evaluate the variability of delimited associations and iv) to describe distribution and habitat conditions of delimited associations in the Eastern Carpathians.

Methods

Study area

The study area includes the Ukrainian Carpathians, the eastern part of the Slovak and Polish Carpathians and the adjacent regions in Hungary (Fig. 1). The western margin of the study area is formed by the Pogórze Przemyskie Mts and Beskid Niski Mts in Poland, Ľubovnianska vrchovina Mts, Ondavská vrchovina Mts and Slánske vrchy Mts in Slovakia and by the Zempléni-hegység Mts in Hungary.

The Ukrainian Carpathians cover an area of approximately 21,000 km² including volcanic highlands of surrounding plains (Kruhlov 2008). They play an important bridge linking the Western and Southern Carpathians. The included mountains comprise a series of low (up to 1000 m) and middle (1500–2061 m) parallel ridges extending from the northwest to the southeast (Tsarnenko 1988). Mountain ranges are separated by main river valleys that spread to the northeast and southwest of the main Carpathian watershed. The northeastern slope of the Ukrainian Carpathians belongs to basins of the Dniester, Prut and Sian rivers and the southwestern slope belongs to the Tisza river basin. The northeastern part of the Ukrainian Carpathians is limited by the Peredkarpat-

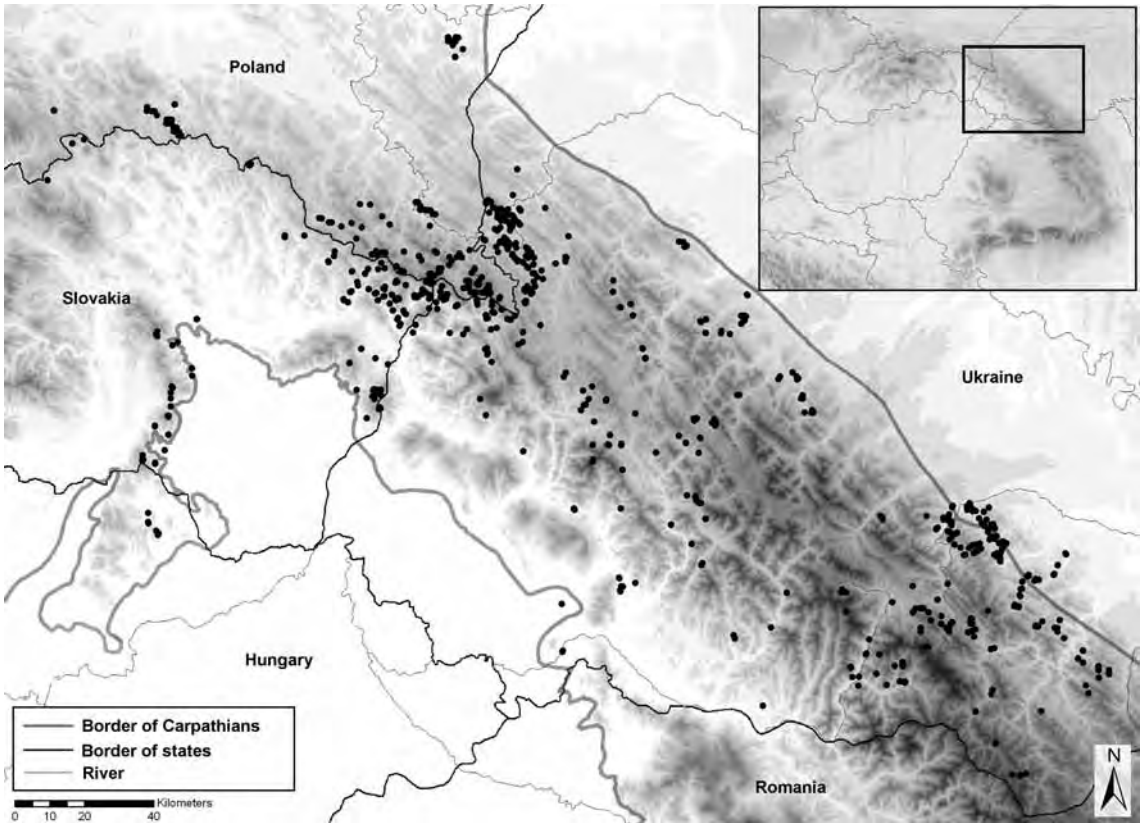

Fig. 1. Location of the study area and distribution of plots in the geographically stratified data set.

tya Highland (400–500 m) while the southwestern part is limited by the Transcarpathian Lowland (Zakarpats'ka nyzovyna, 100–120 m).

The Ukrainian Carpathians are located in the temperate continental climate where Atlantic air masses predominate. Winters are mild, with an average temperature in January of (-3)–(-5)°C. Summers are warm, with an average temperature in July of 18–21°C. The summer months are characterized by high precipitation, and the winter is relatively dry. Frequent cyclones from the west are typical for the region. In the high mountain zone, the climate can be harsh. Average temperatures are 3–5°C lower than in the pre-mountain zone (up to 900 m). Mountain ranges are climatic barriers that separate the warmer Transcarpathian Plain and the cooler Peredkarpattya Highland. Snow covers the high mountain slopes for up to five months of the year (Stepchuk 2011, Kricsfalusy 2013). The whole region is an area with both adequate and excessive moisture as reflected in a dense hydrological network (brooks, streams, rivers). A mixed snow-rain flood regime of water supply is common. The acidic brown soils with lower humus content predominate in the region. Leaching is one of the main physicochemical properties of these soils, which caused high acidity in this area (Malynovski 1980, Holubets et al. 1988, Malynovski & Kricsfalusy 2002). Five climate-vegetation belts (the submontane, the beech forest, the spruce forest, the subalpine and the alpine) are distinguished in the Ukrainian Carpathians (Malynovski 1980). Natural grasslands (tall-herb mountain meadows, highland and alpine grasslands) and subalpine scrub communities occur in the subalpine and alpine belt, notably in the Chornohora massif.

Vegetation sampling

Field sampling was performed between 2009 and 2014 according to principles of the Zürich-Montpellier school (Braun-Blanquet 1964) using a nine-degree cover-abundance scale (Westhoff & van der Maarel 1973). For sampling, sites with homogenous species composition and environmental conditions were chosen. A set of 493 relevés was recorded by L. Borsukevych and K. Danylyuk during the grassland mapping in 2009 and 2010 on plots of 10×10 m within the Kosivskyi, Nadvirnyanskyi, Rakhivskyi, Turkivskyi and Verkhovynskyi districts. Altitude, slope and aspect were estimated for each plot. Another 266 relevés were recorded during 2013 and 2014 on plots of 4×4 m within the whole area of the Ukrainian Carpathians with special attention paid to balanced coverage of variability and distribution of the target vegetation. The percentage cover of herb and cryptogam layers was estimated for each plot. To assist the ecological interpretation of the plots, the litter, open soil, excrements, bare rocks and management regime were evaluated. The following management types were distinguished based on visual observation and interviews with local farmers: mowing (by hand or mowing machine), grazing, fencing, burning, ploughing, fertilisation, mulching, cutting shrubs and irrigation. In addition, historical management before and after 1990 was recorded. Complete phytosociological tables of Ukrainian unpublished relevés (including 724 own relevés, 35 outliers were removed) are listed in Supplements S2–S4. The header data of the unpublished relevés are presented in Supplement S5.

Data analysis

Our own phytosociological relevés together with all accessible published and unpublished relevés of mesic grasslands from the Ukrainian Carpathians and adjacent regions of the Eastern Carpathians formed the initial data set. We used 459 published relevés from the Ukrainian Carpathians (Pawłowski & Walas 1949, Derzhypilsky et al. 2001, Malynovski & Kricsfalusy 2002, Zarzycki 2002, Solomakha et al. 2004, Chorney et al. 2005, Klimuk 2006, Tokaryuk 2009, Škodová et al. 2015), 337 relevés from the Slovak Vegetation Database (Šibík 2012, EU-SK-001 in the Global Index of Vegetation-Plot Databases), 433 relevés from the Polish Vegetation Database (Kącki & Śliwiński 2012, EU-PL-001) and 12 relevés from Hungary (private database of Attila Lengyel, Vácrátót, Hungary). The initial data set containing 2,000 relevés was analysed using the program JUICE 7.0.127 (Tichý 2002). The original cover values were transformed to average percentage covers (r: 1%, +: 2%, 1: 3%, 2m: 4%, 2a: 8%, 2b: 18%, 3: 38%, 4: 68%, 5: 88%).

The outliers were removed from the unstratified data set in several consecutive steps: i) the relevés with less than 8 vascular plant species and plot size outside the range 5–100 m^2 were excluded to maintain the homogeneity of the data set and to minimise negative impact of different plot size on species constancy (Chytrý & Otýpková 2003, Dengler et al. 2009); ii) the Ukrainian relevés from the literature sources outside the study area were excluded after revision of geographical coordinates; iii) the relevés with cover of shrub or tree layers exceeding 25% were excluded; iv) the relevés classified to non-target syntaxa (associations of *Festuco-Brometea*, *Trifolio-Geranietea* and *Calluno-Ulicetea* classes or *Molinietalia caeruleae* order) by the expert system for identification of grassland syntaxa of Slovakia (Janišová et al. 2007, Hegedüšová Vantarová & Škodová 2014) were removed; v) relevés re-sampled from permanent or semi-permanent plots were excluded and vi) the outliers detected by the visual observation in ordination graphs of preliminary gradient analyses [based on the detrended correspondence analysis in Canoco 5 program (Šmilauer & Lepš 2014)] were excluded. After these steps, the data set included 1,856 relevés with 1,045 taxa.

The expert system for identification of grassland syntaxa of Slovakia was used for selection of typical relevés of clearly delimited associations and these were set as the *a priori* groups in the semi-supervised classification. The homogeneity of relevés was checked by the DCA ordination graphs for each cluster and the few outlying relevés were removed from the *a priori* groups. Also, a few relevés not matching the formal definitions in the expert system were approved by the phytosociological experts as typical and included in the *a priori* groups. In total, 214 relevés in 14 *a priori* groups consisting of 4 to 39 typical relevés were selected to represent associations of the target vegetation.

Heterogeneity-constrained resampling (Lengyel et al. 2011, Wiser & de Cáceres 2013) was performed to remove unbalanced distribution of the relevé plots (Knollová et al. 2005). The strata were defined based on the geographical position of individual plots. For each stratum of 3' latitude and 5' longitude (approximately 5.6× 6.1 km), one to ten plots were selected (square-root transformation of species data, number of selected relevés driven by beta diversity expressed by Jaccard dissimilarity with 100 random selections and a Euclidean distance measure). In 46 plots with unknown geographic coordinates the strata were defined according to the relevé author. The relevés selected as typical for *a priori* groups were all included in the final data set without stratification (according to a visual inspection of their distribution they were rather regularly spread within the whole study area). The resampled data set included 952 relevés with 880 taxa. The analysed relevés used in numerical classification and their literature sources are listed in Appendix 1. The identification of outliers (step vi above) was applied once again in the stratified data set and another 19 outliers were removed. Thus, the final data set included 933 relevés with 869 taxa of vascular plants and mosses. The cryptogams, woody species and the taxa determined only at the level of genera (except *Alchemilla* spec. div.) were removed from the data set before the analyses.

The classification process was undertaken in three steps: i) expanding the *a priori* groups by the relevés most similar to typical relevés of each of the 14 *a priori* groups; ii) detection of the optimal number of distinguished clusters; iii) identification and classification of the newly-generated clusters. Semi-supervised classification (Tichý et al. 2014) including 14 *a priori* and one newly-generated cluster was used to expand the *a priori* groups. We performed the K-means analysis with fixed centroids, three pseudo-species cut-off levels (0%, 5% and 25%) and Hellinger transformation. The semi-supervised K-means classification with fixed centroids gave us more interpretable results than classification with non-fixed centroids, which led to more heterogenous clusters. The classification process was repeated in 15 cycles. In this step, a further 338 relevés were assigned to the 14 *a priori* groups, which then contained 552 relevés. In the second step of the classification, the enlarged 14 *a priori* clusters were used with the same parameters as in the previous semi-supervised K-means analysis. Following several cycles of semi-supervised K-means analyses with different number of clusters, we set the final number of distinguished clusters to 25. This number of clusters was enough to distinguish the main types of target vegetation at the level of associations and also some variants. Apart from the 14 *a priori* clusters, five out of 11 newly-generated clusters were recognized as separate vegetation types and included in the synoptic table (Appendix 2). One cluster of the *Deschampsion caespitosae* alliance (11 relevés unclassified by the expert system for identification of grassland syntaxa of Slovakia, but dominated by *Deschampsia cespitosa*, *Holcus mollis* and *Cirsium palustre*) was removed as non-target vegetation from the data set. Relevés of the remaining five newly-generated clusters lacking clear syntaxonomic status and floristic differentiation were assigned to the readily interpretable 19 clusters by an additional supervised K-means classification.

The average number of vascular plants in the delimited vegetation types was calculated only for relevés with plot size of 16–25 m^2. For the clusters containing mainly relevés of larger plot sizes (clusters 1, 7, 18 and 19) the averages were calculated for 100 m^2 plots.

A *detrended correspondence analysis* (DCA, square-root transformation of species cover and down-weighting of rare species) was used to visualize the relationships among the delimited syntaxa. For a comparison of environmental conditions of syntaxa, we calculated plot-based unweighted means of indicator values adapted for the Ukrainian flora (Didukh 2011). The Didukh indicator values (DIV) for light, continentality, thermal climate, nitrogen, soil reaction (acidity) and soil humidity, together with the altitude, were correlated *post-hoc* with the DCA ordination axes. Taxa without specified DIV ecological information are listed in Supplement S6. Spearman correlation coefficients were calculated between DIV, altitude and the first two DCA ordination axes. Bonferroni correction was applied to control the family-wise error rate setting critical values of α as 0.0056 (0.05/9 variables).

To express the species concentration in a vegetation unit, we calculated the *phi* coefficient (Sokal & Rohlf 1995, Chytrý et al. 2002). The number of relevés belonging to all clusters was standardized to an equal size and the size of each target group was set as 5.263% of the total data set (Tichý & Chytrý 2006). Species simultaneously showing $phi \geq 0.20$ and significant concentration in a particular cluster (Fisher's exact test $P < 0.001$) were accepted as diagnostic. Among them, only species with a frequency ≥ 10% in particular clusters were visualized in the synoptic table. The species with frequency > 60% were considered as constant and the species achieving cover ≥ 25% in at least 10% of relevés were considered as dominant for a particular association. Only species with

frequency ≥ 20% in particular clusters were included as «other species» in the synoptic table.

Results

Semi-supervised classification

Fifteen well-differentiated associations in the total number of nineteen clusters (Table 1) were finally distinguished and described. The distribution of all types of mesic grasslands in the study area is shown in Fig. 2 and Fig. 3. We present also some well-defined variants of the *Poo-Trisetetum flavescentis* association, which represent initial, unstable, ruderalized stages in the first years after ploughing. As a non-target vegetation type we decided to classify cluster 19, which shows transitional grasslands of *Deschampsion caespitosae* to *Arrhenatherion elatioris* and *Violion caninae* alliances with higher abundance and cover values of diagnostic species of the *Deschampsion caespitosae* alliance (*Deschampsia cespitosa, Holcus mollis, Cirsium palustre, C. rivulare, Scutellaria galericulata*).

Table 1. Syntaxonomic affiliation of the clusters delimited by the semi-supervised classification.

Molinio-Arrhenatheretea R. Tx. 1937
- *Arrhenatheretalia* R. Tx. 1931
  - *Arrhenatherion elatioris* Luquet 1926
    - *Pastinaco sativae-Arrhenatheretum elatioris* Passarge 1964, ruderalized variant (cluster 1)
    - *Poo-Trisetetum flavescentis* Knapp ex Oberd. 1957
      - var. ruderalized, termophilous (cluster 2)
      - transitions to *Alchemillo-Arrhenatheretum elatioris* (cluster 3)
      - var. typicum (cluster 4)
      - var. ruderalized, nitrophilous (cluster 5)
    - *Anthoxantho odorati-Agrostietum tenuis* Sillinger 1933 (cluster 6)
    - *Betonico officinalis-Trifolietum pannonici* Derzhypilsky et al. ex Zajac et al. hoc loco (cluster 7)
    - *Primulo veris-Agrostietum capillaris* Uhliarová et Janišová 2014 (cluster 8)
  - *Cynosurion cristati* R. Tx. 1947
    - *Plantagini majoris-Lolietum perennis* Beger 1932 (cluster 9)
    - *Lolio perennis-Cynosuretum cristati* R. Tx. 1937 (cluster 10)
- *Molinietalia caerulae* Koch 1926
  - Deschampsion caespitosae Horvatić 1930
    - Transitions to the *Arrhenatherion elatioris* and *Violion caninae* (cluster 19)

Nardetea strictae Rivas Goday in Rivas Goday et Rivas-Mart. 1963
- *Nardetalia strictae* Oberd. ex Preising 1949
  - *Violion caninae* Schwickerath 1944
    - *Festuco rupicolae-Nardetum strictae* Dostál 1933 corr. Ujházy et Kliment 2014 (cluster 11)
    - *Polygalo vulgaris-Nardetum strictae* subass. *caricetosum fuscae* Balátová-Tuláčková in Balátová-Tuláčková et al. 1987 (cluster 12)
    - *Campanulo rotundifoliae-Dianthetum deltoidis* Balátová-Tuláčková 1980 (cluster 13)
    - *Hyperico maculati-Deschampsietum flexuosae* Balátová-Tuláčková 1985 (cluster 14)
  - *Nardo strictae-Agrostion tenuis* Sillinger 1933
    - *Betonico officinalis-Agrostietum capillaris* Blažková et Březina 2003 (cluster 15)
    - *Campanulo abietinae-Nardetum strictae* (Pałczyński 1962) Hadač et al. 1988 (cluster 16)
    - *Antennario dioicae-Nardetum strictae* (Svoboda 1939) Ujházy et Kliment in Janišová et al. 2007 (cluster 17)
  - *Potentillo ternatae-Nardion strictae* Simon 1957
    - *Soldanello hungaricae-Nardetum strictae* Kricsfalusy & Malynovski 2000 (cluster 18)

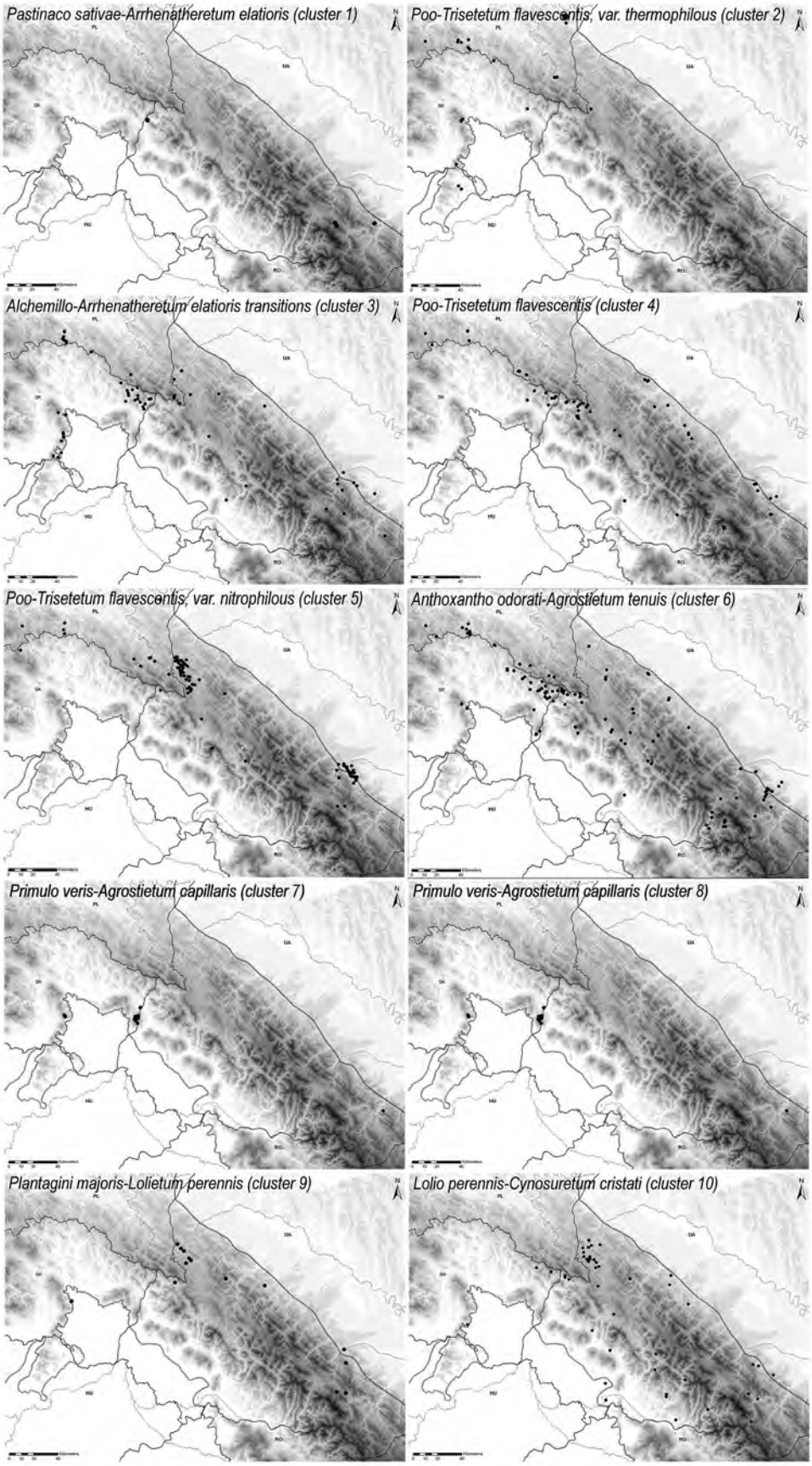

Fig. 2. Distribution of clusters 1–10 in the study area.

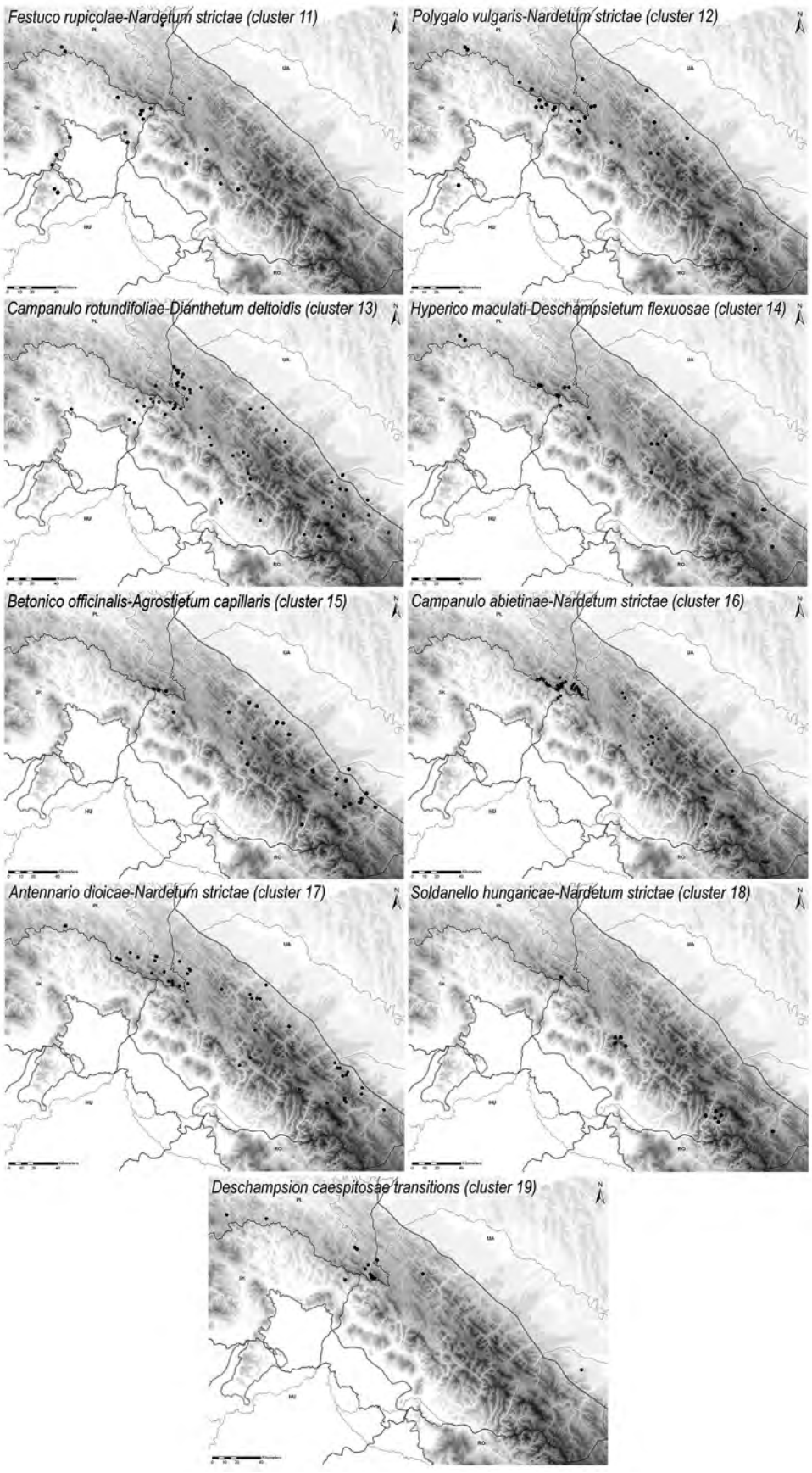

Fig. 3. Distribution of clusters 11–19 in the study area.

The cluster 18 of the *Soldanello hungaricae-Nardetum strictae* is also rated as a non-target vegetation type, differentiated by montane and subalpine species of the *Nardion strictae* alliance (*Potentilla aurea, Festuca picturata, Thymus pulcherrimus, Homogyne alpina, Poa alpina, Cetraria islandica*).

Ordination

The average Didukh indicator values for relevés [light, continentality, thermal climate, nitrogen, soil reaction (acidity) and soil humidity] and altitude were correlated *post-hoc* with the ordination axes to reveal the main environmental gradients in our data (Fig. 4). The first DCA axis was significantly negatively correlated with Didukh indicator values (DIV) for nitrogen (-0.88), soil reaction (-0.86), thermal climate (-0.80), light (-0.67) and continetality (-0.59) and positively correlated with DIV for altitude (0.61). The second ordination axis was negatively correlated with DIV for soil reaction (-0.34). The main environmental gradient was related to altitude and soil parameters, especially soil reaction and nutrient content (nitrogen). The right side of the ordination plot contains relevés of the *Potentillo ternatae-Nardion strictae* (cluster 18), *Nardo-Agrostion* (clusters 15, 16, 17) and *Violion caninae* (clusters 11–14) occurring at higher altitudes and on acid nutrient-poor soils. Relevés from lowland pastures of the *Cynosurion cristati* (clusters 9, 10) and meadows on former arable fields (*Arrhenatherion elatioris*, clusters 1–8, 19) hosting more nutrient demanding species are concentrated on the left side of the plot, where values of altitude decrease and DIV for nitrogen and soil reaction (pH) increase.

Description of the clusters

Cluster 1: *Pastinaco sativae-Arrhenatheretum elatioris*, ruderalized variant (6 relevés)
Author's original classification (number of relevés in the parentheses): *Arrhenatherion elatioris* (5), not clear (1)

Diagnostic species: *Geranium pratense, Rumex confertus, Lamium album, Glechoma hederacea* agg., *Anthriscus sylvestris, Aegopodium podagraria, Symphytum officinale, Arrhenatherum elatius, Heracleum sphondylium, Urtica dioica*
Constant species: *Trifolium pratense, Taraxacum* sect. *Ruderalia, Arrhenatherum elatius, Ranunculus acris, Plantago lanceolata, Heracleum sphondylium, Geranium pratense, Centaurea jacea, Vicia sepium, Veronica chamaedrys, Rumex confertus, Glechoma hederacea* agg., *Dactylis glomerata, Anthriscus sylvestris, Aegopodium podagraria*
Dominant species: *Arrhenatherum elatius, Geranium pratense, Heracleum sphondylium, Colchicum autumnale, Aegopodium podagraria*

This cluster is characterized by meadows at lower altitudes dominated by *Arrhenatherum elatius* and *Geranium pratense*. Eutrophic species (*Heracleum sphondilium, Colchicum autumnale, Aegopodium podagraria* and *Dactylis glomerata*) are constantly present. Other nitrophilous species (*Taraxacum* sect. *Ruderalia, Trifolium pratense, Vicia sepium, Glechoma hederacea* agg., *Rumex confertus, Anthriscus sylvestris*) together with some typical species of mesic grasslands (*Ranunculus acris, Veronica chamaedrys, Leucanthemum vulgare* agg.) are frequent. The eutrophic, deep-rooting species of heavy summer-

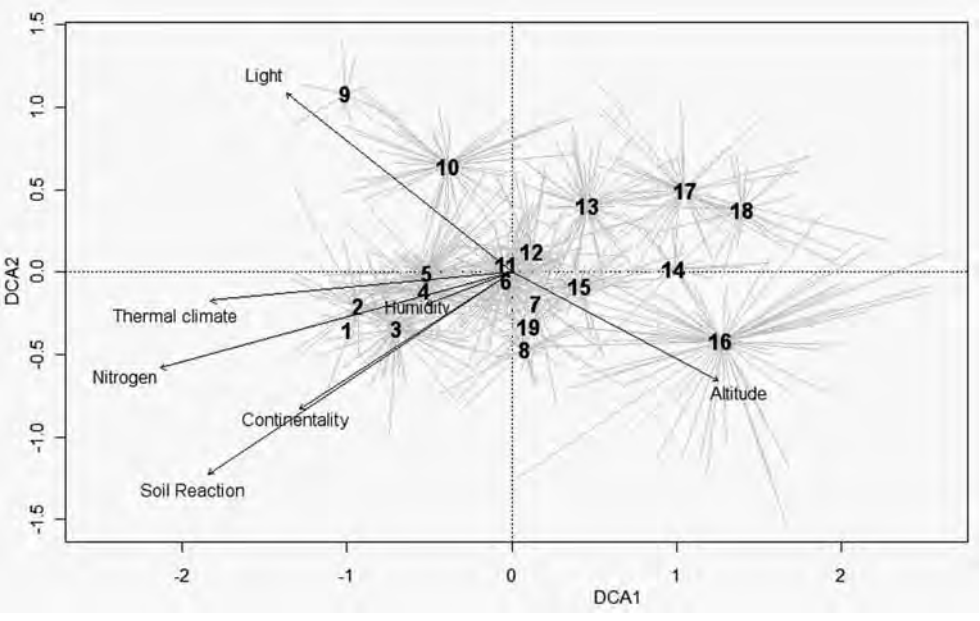

Fig. 4. Detrended correspondence analysis (DCA) of the 933 relevés grouped into 19 clusters. The first two ordination axes with passive projection of Didukh indicator values (DIV) and altitude are shown.

dry soils such as *Symphytum officinale*, *Geranium pratense* and *Heracleum sphondilium* and several ruderal species (*Lamium album*, *Urtica dioica*) are admixtured as well. The moss layer is usually underdeveloped.

These grasslands are regularly mown at least once a year and often extensively grazed. They were sporadically recorded in the Verkhovinskyi, Rakhivskyi and Velykobereznyanskyi districts, always in a ruderalized form with frequent occurrence of *Rumex confertus*, *Lamium album*, *Symphytum officinale* and *Urtica dioica*.

Clusters 2–5: *Poo-Trisetetum flavescentis* (265 relevés)
Author's original classification: *Agrosti-Festucetum rubrae* (1), *Agrostietum vulgaris* (5), *Alchemillo-Arrhenatheretum elatioris* (4), *Arrhenatherion elatioris* (115), *Centaureo-Trifolietum pannonici* (1), *Cynosurion cristati* (4), *Festucetum rubrae* (1), *Gladiolo-Agrostietum capillaris* (6), Lolio *perennis-Cynosuretum cristati* (5), *Poo-Trisetetum flavescentis* (8), *Violion caninae* (4), com. *Agrostis capillaris*, nutrient variant (9), com. *Dactylis glomerata* (1), com. *Festuca pratensis* (1), not clear (100)

Diagnostic species*: *Bromus hordeaceus*, *Phleum pratense*, *Dactylis glomerata*, *Schedonorus pratensis*, *Crepis biennis*, *Trisetum flavescens*, *Rumex thyrsiflorus*, *Vicia cracca*, *Torilis japonica*, *Crepis setosa*, *Galium mollugo* agg., *Lathyrus pratensis*, *Rhinanthus alectorolophus*
Constant species*: *Achillea millefolium* agg., *Plantago lanceolata*, *Dactylis glomerata*, *Agrostis capillaris*, *Veronica chamaedrys*, *Campanula patula*, *Ranunculus acris*, *Anthoxanthum odoratum* agg., *Trifolium repens*, *Leucanthemum vulgare* agg., *Trifolium pratense*, *Rumex acetosa*, *Lotus corniculatus*, *Schedonorus pratensis*, *Taraxacum* sect. *Ruderalia*, *Stellaria graminea*, *Alchemilla* sp. div., *Hypericum maculatum*, *Cerastium fontanum* agg., *Phleum pratense*, *Cruciata glabra*
Dominant species*: *Agrostis capillaris*, *Schedonorus pratensis*

Here, mesic grasslands are distributed mainly on fallows dominated by grasses of nutrient-poor sites (*Agrostis capillaris* and *Anthoxanthum odoratum*) with a frequent occurrence of broad-leaved grasses of nutrient-richer sites (*Trisetum flavescens*, *Dactylis glomerata*, *Phleum pratense*). For the dicotyledonous herbs, *Achillea millefolium* agg., *Plantago lanceolata*, *Veronica chamaedrys*, *Campanula patula*, *Ranunculus acris*, *Anthoxanthum odoratum* agg., *Trifolium repens*, *T. pratense*, *Leucanthemum vulgare* agg. and *Rumex acetosa* are constantly present. The presence of boreal-subatlantic species (*Hypericum maculatum*, *Cruciata glabra*, *Stellaria graminea*, *Phleum pratense*) is typical. There are 21–73 species per plot with 41 vascular species on average. The moss layer consists mainly of *Rhytidiadelphus squarrosus*, *Thuidium delicatulum*, *Atrichum undulatum*, *Plagiomnium affine* and *Brachythecium rutabulum* and reaches a cover between 0 and 95%.

These grasslands are very common, especially in the north-western part of the study area. They mainly occupy sites at altitudes between 450 and 900 m with various aspects and moderate slopes up to 25°. They are usually regularly mown once or twice a year, sometimes also extensively grazed by cows or horses.

Beside the typical variant of *Poo-Trisetetum flavescentis*, we distinguished several variants and transitional grasslands within this association:

i) var. typicum (63 relevés), cluster 4
Beside a characteristic species composition of *Arrhenatherion elatioris* alliance, this variant is differentiated by the species of the nutrient-richer, disturbed sites (*Crepis biennis*, *Poa trivialis*, *Veronica filiformis*, *Rhinanthus alectorolophus*, *Bromus hordaceus*) and by the presence of boreal-subatlantic species (*Hypericum maculatum*, *Cruciata glabra*, *Stellaria graminea*, *Phleum pratense*) together with the periodic occurrence of montane species of the *Polygono bistortae-Trisetion flavescentis* alliance (*Arabidopsis halleri*, *Primula elatior*, *Astrantia major*, *Trollius altissimus*).

The typical variant is very common especially in the northwestern part of the study area where it occupies predominantly north- to east-facing slopes at altitudes between 450 and 1100 m. These grasslands are usually regularly mown once or twice a year, sometimes also extensively grazed by cows or horses.

ii) var. ruderalized, termophilous (37 relevés), cluster 2
Recently abandoned fields with frequent occurrence of thermophilous ruderal (*Torilis japonica*, *Vicia tetrasperma*) and common ruderal (*Cirsium arvense*, *Elytrigia repens*, *Urtica dioica*) species of disturbed sites. The montane species of the *Polygono bistortae-Trisetion flavescentis* alliance characteristic for *Poo-Trisetetum flavescentis* var. *typicum* occur only rarely or are absent.

These ruderalized fallows are common in warmer regions of southern Poland, and only rarely were they recorded in the rest of the study area. They occupy mainly gentle slopes with various aspects from lower to middle altitudes (300–650 m) and are usually regularly mown once or twice a year.

iii) transitions to *Alchemillo-Arrhenatheretum elatioris* (64 relevés), cluster 3
This was delimited by meadows in the submontane and montane belts without marked diagnostic species. They are dominated mainly by broad-leaved grasses (*Schedonorus pratensis*, *Trisetum flavescens*, *Dactylis glomerata*)

* These species are diagnostic for the whole association and were derived from merging clusters 2–5 representing variants of this association, which are separated in the synoptic table.

together with grasses of nutrient-poor sites (*Agrostis capillaris*, *Festuca rubra* agg. and *Anthoxanthum odoratum* agg.). Simultaneously, this vegetation is characterized by lower constancy and cover of *Arrhenatherum elatius*. The species of mesic meadows of the *Arrhenatherion elatioris* alliance (*Achillea millefolium* agg., *Leontodon hispidus*, *Leucanthemum vulgare* agg., *Plantago lanceolata*, *Campanula patula* agg., *Ranunculus acris*, *Lotus corniculatus* agg., *Veronica chamaedrys*, *Trifolium repens*, *T. pratense*, *Taraxacum* sect. *Ruderalia*) are the most frequent. Acidophilous, montane and subxero-thermophilous species are absent. Several species of the genus *Alchemilla* and boreal-subatlantic species (*Stellaria graminea*, *Phleum pratense*, *Hypericum maculatum*, *Cruciata glabra*) are also frequent.

These grasslands were recorded particularly on fallows in the north-western (Turkivskyi district) and north-eastern (Kosivskyi and Nadvirnyanskyi district) parts of the Ukrainian Carpathians. They occupy moderate north-western to eastern slopes at altitudes from 300 to 950 m. These meadows are mown once or twice a year often in combination with slight grazing.

iv) var. ruderalized, nitrophilous (100 relevés), cluster 5
This was delimited by recently abandoned, former fields in the submontane and montane belts without a stable species composition. The floristic composition of *Poo-Trisetetum flavescentis* species contains some species of nutrient-rich and ruderal habitats (*Crepis setosa*, *C. capillaris*, *Rumex thyrsiflorus*, *Galeopsis tetrahit*, *Trifolium hybridum*). The dominant and constant taxa include mainly grasses (*Agrostis capillaris*, *Schedonorus pratensis*, *Anthoxanthum odoratum* agg.) and common species of mesic meadows of the *Arrhenatherion elatioris* alliance (*Achillea millefolium* agg., *Campanula patula*, *Lotus corniculatus*, *Plantago lanceolata*, *Leucanthemum vulgare* agg., *Stellaria graminea*).

These grasslands were recorded in the north-western (Turkivskyi district) and northeastern (Nadvirnyanskyi district) parts of the Ukrainian Carpathians at altitudes between 400 and 900 m, where they occupy moderate slopes (3–15°) with various aspects. They are usually mown once or twice a year and often extensively grazed.

Cluster 6: *Anthoxantho odorati-Agrostietum tenuis* (135 relevés)
Author's original classification: *Anthoxantho odorati-Agrostietum tenuis* (6), *Arrhenatherion elatioris* (3), *Carlino-Dianthetum deltoidis* (7), *Gladiolo-Agrostietum capillaris* (1), *Pohlio-Callunion* (1), com. *Agrostis capillaris*, nutrient-poor variant (22), not clear (95)

Diagnostic species: *Sisyrinchium montanum*
Constant species: *Festuca rubra* agg., *Lotus corniculatus*, *Leucanthemum vulgare* agg., *Achillea millefolium* agg., *Agrostis capillaris*, *Plantago lanceolata*, *Polygala vulgaris*, *Anthoxanthum odoratum* agg., *Potentilla erecta*, *Thymus pulegioides*, *Pimpinella saxifraga* agg., *Leontodon hispidus*, *Centaurea jacea*, *Briza media*, *Cruciata glabra*, *Carex pallescens*, *Trifolium repens*, *Campanula patula*, *Luzula campestris* agg., *Trifolium pratense*, *Ranunculus acris*, *Hypericum maculatum*, *Prunella vulgaris*, *Veronica chamaedrys*, *Viola canina*, *Alchemilla* spec. div., *Rumex acetosa*, *Knautia arvensis*
Dominant species: *Agrostis capillaris*, *Festuca rubra* agg., *Leontodon hispidus*

This association was delimited by mesic nutrient-poor meadows or grazed meadows containing species typical of several alliances including the *Arrhenatherion elatioris*, *Cynosurion cristati* and *Violion caninae*. The middle values along the main environmental gradients in combination with regular mowing and grazing reflect the extraordinary species richness of this community. The stands are usually dominated by *Festuca rubra* agg., *Agrostis capillaris*, *Anthoxanthum odoratum* agg., *Briza media*, *Carex pallescens*, *Luzula campestris* agg., *Dactylis glomerata* and *Schedonorus pratensis*. Along with mesophilous species of the *Arrhenatherion elatioris* alliance (*Plantago lanceolata*, *Lotus corniculatus* agg., *Achillea millefolium*, *Leucanthemum vulgare* agg., *Leontodon hispidus*, *Cruciata glabra*, *Centaurea jacea*, *Pimpinella saxifraga*, *Trifolium pratense*, *T. repens*) some herbs of the *Violion caninae* alliance (*Polygala vulgaris*, *Thymus pulegioides*, *Potentilla erecta* and *Viola canina*) occur with higher constancy. The grasses *Nardus stricta* and *Danthonia decumbens* are frequent on grazed plots, while *Trollius altissimus* and *Deschampsia cespitosa* occur mainly at higher altitudes. The species of nutrient-rich habitats (*Cynosurus cristatus*, *Taraxacum* sect. *Ruderalia* and *Prunella vulgaris*) are common in intensively grazed stands. The mean number of vascular plant species per a relevé plot is 46 (range 31–66). The cover of the moss layer varies between 0 and 90% with *Rhytidiadelphus squarrosus*, *Thuidium delicatulum*, *Climacium dendroides* and *Plagiomnium affine* being the most frequent species.

This association belongs to the most common grasslands in the Ukrainian Carpathians and is distributed from the colline to the montane belts (300–1000 m) on slopes with various inclination and aspect. They occur more frequently in the eastern part of the study area, where the impact of cooperative agricultural management was less pronounced. The stands are regularly mown once or twice a year, occasionally they are also grazed after the first cut.

Cluster 7: *Betonico officinalis-Trifolietum pannonici* ass. nov. hoc loco (64 relevés)
Nomenclatural type:
Sheshory, Lebedin, Ivano-Frankivsk district, 19 July 2006, 48.21°N, 24.56°E, total vegetation cover 95%, L.

Derzhypilsky (Derzhypilsky et al. 2011, Table 9.10, relevé 16); holotypus hoc loco
Agrostis capillaris 2a, *Centaurea phrygia* ssp. *carpatica* (merged to *Centaurea phrygia* agg. in our data set) 2a, *Astrantia major* 1, *Briza media* 1, *Carex pallescens* 1, *Galium verum* agg. 1, *Gentiana asclepiadea* 1, *Malaxis monophyllos* 1, *Nardus stricta* 1, *Potentilla erecta* 1, *Stachys officinalis* (Syn. *Betonica officinalis*) 1, *Trifolium medium* 1, *T. pannonicum* 1, *Anthoxanthum odoratum* agg. +, *Anthyllis vulneraria* +, *Arnica montana* +, *Campanula glomerata* agg. +, *C. patula* +, *C. persicifolia* +, *C. serrata* +, *Carlina acaulis* +, *Centaurea phrygia* +, *Colchicum autumnale* +, *Cruciata glabra* +, *Dactylorhiza fuchsii* ssp. *fuchsii* +, *D. majalis* +, *Festuca rubra* agg. +, *Gymnadenia conopsea* +, *Hypericum maculatum* +, *Leucanthemum vulgare* agg. +, *Listera ovata* +, *Luzula luzuloides* +, *Pimpinella saxifraga* agg. +, *Plantago lanceolata* +, *Platanthera bifolia* +, *Polygala vulgaris* +, *Ranunculus polyanthemos* +, *Rhinanthus angustifolius* +, *Rumex acetosella* +, *Stellaria graminea* +, *Traunsteinera globosa* +, *Trollius altissimus* +

Author's original classification: *Agrosti-Festucetum rubrae*: (2), *Arrhenatherion elatioris* (17), *Centaureo-Trifolietum pannonici* (20), *Gladiolo-Agrostietum capillaris* (2), *Violion caninae* (1), com. *Agrostis capillaris typicum* (1), com. *Brachypodium pinnatum-Trifolium pannonicum* (3), com. *Nardus stricta-Agrostis tenuis* (1), com. *Nardus tricta-Trifolium pannonicum* (2), com. *Festuca rubra* (8), com. *Festuca pratensis* (5), not clear (1)

Diagnostic species: *Campanula glomerata* agg., *Gladiolus imbricatus, Ononis spinosa* subsp. *hircina, Trifolium alpestre, Peucedanum oreoselinum, Stellaria holostea, Helianthemum canum*
Constant species: *Agrostis capillaris, Plantago lanceolata, Leucanthemum vulgare* agg., *Briza media, Potentilla erecta, Stachys officinalis, Achillea millefolium* agg., *Centaurea jacea, Pimpinella saxifraga* agg., *Lotus corniculatus, Cruciata glabra, Carlina acaulis, Rhinanthus minor, Anthoxanthum odoratum* agg., *Galium verum* agg.
Dominant species: *Agrostis capillaris, Festuca rubra* agg.

This association was delimited by montane grasslands that share features of the *Arrhenatherion elatioris* and *Violion caninae* alliances and the *Festuco-Brometea* class. The stands are characterized by occurrence of mesic (*Agrostis capillaris, Plantago lanceolata, Leucanthemum vulgare* agg., *Achillea millefolium* agg.), acidophilous (*Potentilla erecta, Polygala vulgaris*) as well as montane species of the *Polygono bistortae-Trisetion flavescentis* alliance (*Astrantia major, Gentiana asclepiadea, Campanula serrata*). Several thermophilous species (*Carlina acaulis, Trifolium pannonicum, Ononis spinosa* subsp. *hircina, Helianthemum canum*) occur with higher constancy. The cover of the moss layer varies between 1 and 80%. There are 37 vascular species in a 100 m^2 plot (range 23–58 species) on average.

These grasslands occur mainly on steeper (10–30°) slopes of various aspect, at altitudes between 500 and 1000 m. They are distributed in the Rakhivskyi, Kosivskyi and Putilskyi districts and are usually regularly mown and sometimes extensively grazed by cows or horses.

Cluster 8: *Primulo veris-Agrostietum capillaris* (24 relevés)
Author's original classification: com. *Festuca rubra* (1), *Anthoxantho-Agrostietum primuletosum veris* (23)

Diagnostic species: *Cruciata glabra, Briza media, Centaurea scabiosa, Plantago media, Primula veris, Brachypodium pinnatum, Dianthus carthusianorum* agg., *Valeriana officinalis, Trifolium rubens, Iris graminea, Tragopogon pratensis* subsp. *orientalis, Knautia arvensis, Silene nutans, Succisa pratensis, Arabis hirsuta* agg., *Laserpitium latifolium, Ajuga genevensis, Thalictrum lucidum, Hieracium sabaudum, Campanula cervicaria, Euphrasia rostkoviana* agg., *Carex montana, Campanula rapunculoides, Phleum phleoides, Vicia cassubica, Convallaria majalis, Dactylorhiza sambucina, Silene vulgaris, Anemone sylvestris, Anemone ranunculoides, Serratula tinctoria, Silene viscaria, Anacamptis morio, Viola odorata, Lilium martagon, Orchis mascula, Sedum sexangulare, Lathyrus niger, Mercurialis perennis*
Constant species: *Polygala vulgaris, Leucanthemum vulgare* agg., *Cruciata glabra, Trifolium montanum, Stachys officinalis, Rumex acetosa, Briza media, Achillea millefolium* agg., *Primula veris, Potentilla erecta, Plantago media, Plantago lanceolata, Filipendula vulgaris, Centaurea scabiosa, Carlina acaulis, Trifolium pratense, Galium verum* agg., *Dianthus carthusianorum* agg., *Brachypodium pinnatum, Thymus pulegioides, Rhinanthus minor, Leontodon hispidus, Festuca rubra* agg., *Centaurea jacea, Anthoxanthum odoratum* agg., *Viola canina, Valeriana officinalis* agg., *Campanula patula, Agrostis capillaris, Veronica chamaedrys, Trifolium rubens, Pimpinella saxifraga* agg., *Tragopogon pratensis* subsp. *orientalis, Ranunculus acris, Prunella vulgaris, Pilosella bauhinii, Luzula campestris* agg., *Lotus corniculatus, Knautia arvensis, Iris graminea, Silene nutans, Hypericum perforatum, Dactylis glomerata, Astrantia major*
Dominant species: *Agrostis capillaris, Stachys officinalis*

Here, grasslands are characterized by frequent mesic (*Leucanthemum vulgare* agg., *Acetosa pratensis, Achillea millefolium* agg.), subxerophilous (*Campanula glomerata* agg., *Filipendula vulgaris, Colymbada scabiosa*) and acidophilous (*Potentilla erecta, Viola canina, Danthonia decumbens*) species. Also several species of thermophilous oak forests (*Trifolium rubens, Iris graminea, Campanula cervicaria, Trifolium pannonicum, Thalictrum luci-*

dum, *Valeriana officinalis*, *Stachys officinalis*) are present, which differentiate them from other grasslands of the *Arrhenatherion elatioris* alliance.

The community represents a specific type of meso-subxerophilous grasslands. Recently, the major part of these meadows are abandoned and threatened by extinction. The mean number of vascular plant species in a relevé plot was 61 (range 54–66).

Cluster 9: *Plantagini majoris-Lolietum perennis* (14 relevés)
Author's original classification: *Arrhenatherion elatioris* (1), *Cynosurion cristati* (9), *Lolio perennis-Cynosuretum cristati* (1), not clear (3)

Diagnostic species: *Prunella vulgaris*, *Trifolium repens*, *Plantago major*, *Argentina anserina*, *Polygonum aviculare* agg., *Matricaria discoidea*
Constant species: *Trifolium repens*, *Taraxacum* sect. *Ruderalia*, *Ranunculus repens*, *Prunella vulgaris*, *Lolium perenne*, *Bellis perennis*, *Cynosurus cristatus*, *Achillea millefolium* agg., *Scorzoneroides autumnalis*, *Plantago major*, *Plantago lanceolata*, *Ochlopoa annua*, *Cerastium fontanum* agg., *Agrostis capillaris*
Dominant species: *Lolium perenne*, *Trifolium repens*

This species-poor vegetation type with a homogenous structure develops on disturbed pastures frequently trampled and manured by cattle. The dominant grass *Lolium perenne* together with some subdominant species (*Cynosurus cristatus*, *Trifolium repens*, *Prunella vulgaris*, *Bellis perennis*) are well adapted to strong trampling and high soil nutrient content. Species tolerating disturbances (*Ranunculus repens*, *Prunella vulgaris*, *Plantago major*, *Scorzoneroides autumnalis*, *Argentina anserina*) together with species of mesic grasslands (*Achillea millefolium* agg., *Plantago lanceolata*, *Agrostis capillaris*, *Ranunculus acris*, *Trifolium pratense*, *Stellaria graminea*) usually form a short lawn due to intensive grazing. Occasionally, some species of the *Matricario matricarioidis-Polygonion arenastri* alliance are also common as they are well adapted to grazing and trampling (*Ochlopoa annua*, *Matricaria discoidea* and *Polygonum aviculare* agg.). The ruderal and segetal species (*Cirsium arvense*, *Elytrigia repens*, *Viola tricolor*, *Equisetum arvense*) expand mainly on disturbed soils. There are on average 28 vascular species in a relevé (range 21–33 species). The cover of moss layer is usually low (1–30%), *Thuidium delicatulum*, *Eurhynchium hyans* and *Calliergonella cuspidata* are the most frequent species.

Intensively grazed pastures were recorded in the northern and north-western part of the Ukrainian Carpathians mainly in the Turkivskyi district at altitudes from 280 to 950 m. Low slopes along river flood-plains are typical habitats of this vegetation.

Cluster 10: *Lolio perennis-Cynosuretum cristati* (53 relevés)
Author's original classification: *Agrosti-Festucetum rubrae* (2), *Arrhenatherion elatioris* (1), *Calamagrostion arundinaceae* (1), *Cynosurion cristati* (7), *Festucetum rubrae* (1), *Lolio perennis-Cynosuretum cristati* (17), *Violion caninae* (6), com. *Agrostis capillaris*, nutrient variant (2), not clear (16)

Diagnostic species: *Setaria viridis*
Constant species: *Trifolium repens*, *Achillea millefolium* agg., *Agrostis capillaris*, *Scorzoneroides autumnalis*, *Prunella vulgaris*, *Cerastium fontanum* agg., *Plantago lanceolata*, *Taraxacum* sect. *Ruderalia*, *Lotus corniculatus*, *Trifolium pratense*, *Festuca rubra* agg., *Cynosurus cristatus*, *Ranunculus acris*, *Bellis perennis*, *Lolium perenne*, *Anthoxanthum odoratum* agg.
Dominant species: *Trifolium repens*, *Cynosurus cristatus*

The stands of this association have a higher abundance of species more typical for the *Molinio-Arrhenatheretea* class than *Plantagini-Lolietum* association, which is influenced especially by lower intensity of grazing. Common species of mesic meadows (*Agrostis capillaris*, *Festuca rubra* agg., *Leontodon hispidus* and *Anthoxanthum odoratum* agg.) are usually dominant in this vegetation. However, the floristic composition changes in favour of nitrophilous and trampling-tolerant species (*Lolium perenne*, *Cynosurus cristatus*, *Bellis perennis*, *Plantago major*, *Scorzoneroides autumnalis*) when the grazing becomes more intensive. Other mesic grasslands species (*Achillea millefolium* agg., *Prunella vulgaris*, *Plantago lanceolata*, *Trifolium pratense*, *T. repens*, *Lotus corniculatus* agg., *Taraxacum* sect. *Ruderalia*, *Ranunculus acris*, *Leucanthemum vulgare* agg.) can also be frequent. The ruderal and segetal species (*Viola tricolor*, *Equisetum arvense*, *Setaria viridis*, *Cirsium vulgare*, *C. arvense*) expand after more intense soil disturbance. The average number of vascular species per relevé plot is 35 (range 24–51 species). In the moss layer covering 1 to 60% of the soil surface *Thuidium delicatulum*, *Rhytidiadelphus squarossus*, *Atrichum undulatum* and *Pleurozium schreberi* are most frequent.

The stands of this vegetation are very common within the whole study area. They are most frequent in the Turkivskyi district at altitudes between 150 and 1000 m. Typical habitats are along the roads and on river terraces with slopes below 10°.

Cluster 11: *Festuco rupicolae-Nardetum strictae* (23 relevés)
Author's original classification: *Carlino-Dianthetum deltoidis* (2), *Festuco rupicolae-Nardetum strictae* (2), not clear (19)

Diagnostic species: *Ranunculus polyanthemos, Fragaria viridis, Festuca stricta* subsp. *sulcata, Viola hirta, Polygala comosa, Avenula pubescens, Potentilla heptaphylla*
Constant species: *Anthoxanthum odoratum* agg., *Achillea millefolium* agg., *Thymus pulegioides, Ranunculus polyanthemos, Briza media, Viola canina, Potentilla erecta, Pimpinella saxifraga* agg., *Luzula campestris agg., Leontodon hispidus, Festuca rubra* agg., *Carex pallescens, Leucanthemum vulgare* agg., *Centaurea jacea, Trifolium pratense, Plantago lanceolata, Lotus corniculatus, Agrostis capillaris, Ranunculus acris, Polygala vulgaris, Galium verum* agg., *Danthonia decumbens*
Dominant species: *Rhytidiadelphus squarrosus* (E_0), *Festuca rubra* agg.

In this association, thermophilous, oligotrophic low-productive pastures are dominated by low oligotrophic grasses such as *Agrostis capillaris, Festuca rubra* agg., *Anthoxanthum odoratum* agg. and *Briza media* but usually without a single dominant species. The herb layer is formed both by species of the *Nardetalia strictae* (*Potentilla erecta, Carex pallescens, Polygala vulgaris, Veronica officinalis, Nardus stricta, Danthonia decumbens, Dianthus deltoides*) and the *Arrhenatheretalia elatioris* (*Leucanthemum vulgare* agg., *Trifolium pratense, Lotus corniculatus, Centaurea jacea, Veronica chamaedrys, Galium mollugo* agg., *Knautia arvensis*) orders. It is enriched by subxerophilous and termophilous species of pastures such as *Euphorbia cyparissias, Hypericum perforatum, Agrimonia eupatoria, Fragaria viridis, Festuca stricta* subsp. *sulcata, Jacobaea vulgaris* and *Daucus carota.* Termophilous broadleaved woody species are also typically admixed in these grasslands (*Ononis spinosa, Rosa canina, Pyrus communis* agg., *Prunus spinosa*). Species richness is about 45 (32–63) species in the herb layer. Moss layer is usually well developed (covering 50–70%). The most frequent are *Rhytidiadelphus squarossus, Pleurozium schreberi, Hylocomnium splendens, Abietinella abietina* and *Eurhynchium hians.*

The meadows and pastures of this association were sporadically recorded on gentle to steep slopes (below 25°) in regions influenced by a Pannonian climate. It is characteristic of the south-western part of the Ukrainian Carpathians to the north from Mukachevo (in the Svalyavskyi, Irshavskyi, Volovetskyi and Mizhirskyi districts), where this vegetation is probably more frequent and under-represented in our data. It was rarely recorded in the Turkivskyi, Velykobereznyanskyi and Verkhovinskyi districts. The stands typically occur at low or medium altitudes (280–700 m), and below 400 m on various aspects, whereas at higher altitudes they occur predominantly on south-facing slopes.

Cluster 12: *Polygalo vulgaris-Nardetum strictae caricetosum fuscae* (32 relevés)
Author's original classification: *Arrhenatherion elatioris* (3), *Gladiolo-Agrostietum capillaris* (2), *Leontodono autumnalis-Nardetum* (1), *Polygalo vulgaris-Nardetum strictae* (6), *Violion caninae* (2), com. *Agrostis capillaris typicum* (1), not clear (17)

Diagnostic species: *Carex panicea, Silene flos-cuculi, Carex nigra, Carex flava* agg., *Climacium dendroides* (E_0), *Juncus conglomeratus, Dactylorhiza majalis, Carex flacca, Agrostis canina, Carex echinata,*
Constant species: *Potentilla erecta, Nardus stricta, Anthoxanthum odoratum* agg., *Achillea millefolium* agg., *Agrostis capillaris, Ranunculus acris, Plantago lanceolata, Festuca rubra* agg., *Carex panicea, Carex pallescens, Briza media, Luzula campestris* agg., *Cruciata glabra, Prunella vulgaris, Leontodon hispidus, Polygala vulgaris, Leucanthemum vulgare* agg., *Alchemilla* spec. div., *Trifolium repens, Centaurea jacea*
Dominant species: *Nardus stricta, Rhytidiadelphus squarrosus* (E_0)

These grasslands are characterized by the dominance of oligotrophic mesophilous grasses (*Nardus stricta, Agrostis capilllaris, Anthoxanthum odoratum* agg., *Briza media*) and constant occurrence of *Violion caninae* and *Nardetalia strictae* species (*Polygala vulgaris, Luzula campestris* agg., *Danthonia decumbens, Viola canina, Carex pallescens, C. pilulifera, Potentilla erecta*). Species of semi-wet and wet grasslands (*Carex nigra, C. panicea, Silene flos-cuculi, Myosotis scorpioides* agg., *Holcus lanatus*) are constantly admixed. A set of other hygrophilous species complete a large group of diagnostic species, especially oligotrophic species of *Cyperaceae* (*Carex flava* agg., *C. flacca* and *C. echinata*) and *Juncaceae* (*Juncus effusus, J. conglomeratus*). The composition of the dicotyledons is completed by common species of mesic grasslands (*Plantago lanceolata, Achillea millefolium* agg., *Prunella vulgaris, Ranunculus acris, Cruciata glabra, Leontodon hispidus*). There are 44 vascular plants (range 25–63 species) on average in a relevé plot. The moss layer is usually well developed (5–85%). The most frequent species are *Thuidium delicatulum, Rhytidiadelphus squarossus, Climacium dendroides, Hylocomnium splendens, Atrichum undulatum* and *Pleurozium schreberi.*

These subhygrophilous communities occur on low-production, regularly grazed or mown, unfertilized meadows. The distribution area in the Ukrainian Carpathians includes almost flat sites in the valleys and gentle slopes (up to 10°) at altitudes between 500 and 700 m, with various aspects. The association was recorded mainly in the northwestern part of the study area (the Velykobereznyanskyi and Turkivskyi district), and rarely in other regions.

Cluster 13: *Campanulo rotundifoliae-Dianthetum deltoidis* (71 relevés)
Author's original classification: *Arrhenatherion elatioris* (1), *Campanulo rotundifoliae-Dianthetum deltoidis* (11),

Festucetum rubrae (1), *Hypochaerido uniflorae-Nardetum strictae* (1), *Pohlio-Callunion* (2), *Violion caninae* (19), com. *Agrostis capillaris* nutrient-poor variant (1), com. *Festuceto rubrae-Cynosuretum agrostietosum* (1), com. *Laserpitium alpinum-Agrostis tenuis* (1), com. *Nardus stricta-Agrostis tenuis* (1), not clear (32)

Diagnostic species: *Pilosella officinarum, Veronica officinalis*
Constant species: *Agrostis capillaris, Nardus stricta, Achillea millefolium* agg., *Thymus pulegioides, Potentilla erecta, Plantago lanceolata, Pilosella officinarum, Polygala vulgaris, Leucanthemum vulgare* agg., *Danthonia decumbens, Anthoxanthum odoratum* agg., *Prunella vulgaris, Cruciata glabra, Viola canina, Lotus corniculatus, Veronica officinalis, Carex pallescens, Luzula campestris* agg., *Trifolium repens, Festuca rubra* agg., *Briza media, Campanula patula, Hypericum maculatum*
Dominant species: *Nardus stricta, Pleurozium schreberi* (E_0)

This association is represented by pastures and meadows with variable spatial structure depending on management. Beside the dominant *Nardus stricta*, *Festuca rubra* agg. and *Agrostis capillaris*, numerous oligotrophic and acidophilous species of the *Violion caninae* alliance (*Danthonia decumbens*, *Veronica officinalis*, *Pilosella officinarum*, *Thymus pulegioides*, *Viola canina*, *Luzula campestris*) and *Nardetalia strictae* order (*Potentilla erecta*, *Pimpinella saxifraga*, *Carex pallescens*, *C. pilulifera*) prevail in the species composition. The association is characteristic by coexistence of oligotrophic and mesotrophic meadow species of the *Arrhenatherion elatioris* alliance (*Leucanthemum vulgare* agg., *Veronica chamaedrys*, *Centaurea jacea*, *Trifolium pratense*, *Campanula patula*). Strong competitive species (*Nardus stricta*, *Hypericum maculatum*, *Potentilla erecta*, *Calluna vulgaris*, *Vaccinium myrtillus*, *Calamagrostis epigejos*, *Brachypodium pinnatum*) with some woody species (*Juniperus communis*, *Picea abies*, *Betula pendula*, *Rubus* spec. div. and *Pinus sylvestris*) are more abundant and sometimes achieve dominance in ungrazed plots. The average number of vascular plant species per relevé is 37 (range 17–60 species). The moss layer is usually well developed but with variable cover (1–80%). *Pleurozium schreberi*, *Rhytidiadelphus squarossus*, *Thuidium delicatulum* and *Hylocomium splendens* are the most frequent and dominant species.

These oligotrophic, low-production pastures occur on moderate or steep slopes with various aspects, mostly at altitudes of 400–800 m within the whole study area, where they belong to the most widespread communities. At higher altitudes and cold climatic regions this vegetation forms transitions to communities of the *Nardo strictae-Agrostion tenuis* alliance. At lower altitudes and in the southern part of the Carpathians it is replaced by a more thermophilous community *Festuco rupicolae-Nardetum strictae*. Some stands are transitional to the floristically most similar *Anthoxantho odorati-Agrostietum tenuis* and *Betonico officinalis-Agrostietum capillaris* associations.

Cluster 14: *Hyperico maculati-Deschampsietum flexuosae* (19 relevés)
Author's original classification: *Arrhenatherion elatioris* (1), *Calluno-Nardetum strictae* (3), *Festucetum rubrae* (1), *Hieracio lachenalii-Nardetum strictae* (1), *Hypochaerido uniflorae-Nardetum strictae* (19), *Leontodono autumnalis-Nardetum* (3), not clear (11)

Diagnostic species: *Hypericum maculatum*, *Carex pilulifera*
Constant species: *Potentilla erecta*, *Hypericum maculatum*, *Nardus stricta*, *Agrostis capillaris*, *Festuca rubra* agg., *Anthoxanthum odoratum* agg., *Vaccinium myrtillus*, *Luzula campestris* agg., *Carex pilulifera*, *Veronica officinalis*, *Carex pallescens*, *Rumex acetosa*, *Luzula luzuloides*
Dominant species: *Nardus stricta*, *Festuca rubra* agg., *Agrostis capillaris*, *Hypericum maculatum*

This association is delimited by low-production stands dominated by *Nardus stricta* accompanied by oligotrophic grasses (*Festuca rubra* agg., *Agrostis capillaris*, *Anthoxanthum odoratum*). Forbs *Hypericum maculatum* and *Potentilla erecta* indicate low grazing intensity or abandonment. A high proportion of acidophytes (especially *Vaccinium myrtillus*, *V. vitis-idaea*, *Luzula luzuloides*, *Carex pilulifera*) is typical. Other common species of the *Violion caninae* alliance and *Nardetalia strictae* order (*Danthonia decumbens*, *Luzula campestris* agg., *Veronica officinalis*, *Carex pallescens*, *Thymus pulegioides* and *Polygala vulgaris*) are frequent. Sporadically occurring montane species (*Solidago virgaurea* subsp. *minuta*, *Hypochaeris uniflora*, *Potentilla aurea*, *Poa chaixii*, *Gentiana asclepiadea*) contribute to the overall floristic variability. The average number of vascular plant species in a relevé plot is 27 (range 20–35 species). The moss layer is usually well developed (5–60%). The most frequent mosses are *Pleurozium schreberi*, *Rhytidiadelphus squarossus*, *Hylocomnium splendens*, *Dicranum bonjeani*, *Thuidium delicatulum* and species of *Polytrichum*.

This vegetation occurs at medium altitudes from submontane to montane belts up to 1100 m, predominantly on mild slopes of various aspect. The distribution area reaches from the flysch mountains of north-eastern Slovakia through adjacent ranges of the Stuzhytsya and Bieszczady Mts (rarely also in the Turkivskyi, Dolynskyi and Mizhirskyi districts) to the Kosivskyi district in the east.

Cluster 15: *Betonico officinalis-Agrostietum capillaris* (38 relevés)
Author's original classification: *Agrostis-Festucetum rubrae* (1), *Anthoxantho odorati-Agrostietum tenuis* (1), *Arrhenatherion elatioris* (1), *Betonico officinalis-Agrostietum capillaris* (2), *Nardo-Festucetum rubrae* (1), *Trifolio medii-Melampyretum nemorosi* (1), *Violion caninae* (3), com. *Agrostis capillaris* (5), com. *Luzula luzuloides-Festuca rubra* (2), com. *Festuceto rubrae-Cynosuretum agrostietosum* (1), not clear (20)

Diagnostic species: *Centaurea phrygia* agg., *Gymnadenia conopsea, Rhytidiadelphus squarrosus* (E_0), *Trollius altissimus*
Constant species: *Agrostis capillaris, Potentilla erecta, Anthoxanthum odoratum* agg., *Hypericum maculatum, Festuca rubra* agg., *Cruciata glabra, Leucanthemum vulgare* agg., *Plantago lanceolata, Achillea millefolium* agg., *Thymus pulegioides, Prunella vulgaris, Trifolium repens, Carex pallescens, Luzula campestris* agg., *Lotus corniculatus, Rumex acetosa, Polygala vulgaris, Centaurea phrygia* agg., *Briza media, Veronica chamaedrys, Trifolium pratense, Campanula patula, Nardus stricta, Gymnadenia conopsea, Gentiana asclepiadea, Stellaria graminea, Centaurea jacea*
Dominant species: *Festuca rubra* agg., *Agrostis capillaris, Rhytidiadelphus squarrosus* (E_0), *Nardus stricta, Pleurozium schreberi* (E_0)

This association represents species-rich grasslands (mean number of species in a relevé plot being 46, range 37–66) dominated by *Agrostis capillaris* and other oligotrophic grasses *(Festuca rubra* agg., *Briza media*, *Anthoxanthum odoratum*, *Nardus stricta*), *Potentilla erecta* and taller forbs (*Stachys officinalis, Centaurea phrygia* agg., *Pimpinella saxifraga* and *Filipendula vulgaris*). A common feature of these grasslands is the coexistence of montane species of the *Nardo strictae-Agrostion tenuis* (*Gentiana asclepiadea*, *Gymnadenia conopsea*, *Pilosella aurantiaca*, *Campanula serrata*, *Vaccinium myrtillus*, *Solidago virgaurea*) and *Polygono bistortae-Trisetion flavescentis* alliances (*Astrantia major*, *Trollius altissimus*, *Pimpinella major*) with oligotrophic submontane species of the *Violion caninae* alliance (*Polygala vulgaris*, *Thymus pulegioides*, *Carex pallescens*, *Danthonia decumbens*) and also mesotrophic meadow species of the *Arrhenatheretalia* order (*Leucanthemum vulgare* agg., *Gladiolus imbricatus*, *Centaurea jacea*, *Lotus corniculatus* agg., *Trifolium pratense*, *Dactylis glomerata*, *Rhinanthus minor*). The moss layer is usually well developed (cover 5–90%) with *Rhytidiadelphus squarrosus*, *Pleurozium schreberi* and *Thuidium delicatulum*.

This association also represents a transitional community between the *Nardo-Agrostion tenuis*, *Polygono bistortae-Trisetion flavescentis* and *Arrhenatherion elatioris* alliances. The stands are most frequent between 500 to 1100 m elevation, on slopes with various aspects. They are regularly mown once or twice a year and less influenced by grazing than the other associations of the alliance. The association is found mainly in the eastern part of the Ukrainian Carpathians (the Rakhivskyi, Kosivskyi and Verkhovinskyi districts), but less frequently in the Skolivskyi and Dolynskyi districts.

Cluster 16: *Campanulo abietinae-Nardetum strictae* (77 relevés)
Author's original classification: *Campanulo abietinae-Nardetum strictae* (8), *Festucetum rubrae* (1), *Hieracio lachenalii-Nardetum strictae* (1), *Hypochaerido uniflorae-Nardetum strictae* (25), com. *Arnica montana-Nardus stricta* (1), com. *Luzula luzuloides-Festuca rubra* (4), com. *Laserpitium alpinum-Agrostis tenuis* (2), not clear (34)

Diagnostic species: *Hypochaeris uniflora, Solidago virgaurea, Phyteuma spicatum, Achillea distans* agg., *Podospermum roseum, Hieracium lachenalii, Dianthus barbatus, Anemone nemorosa, Rumex alpestris, Hieracium umbellatum, Thymus alpestris, Knautia dipsacifolia, Phleum rhaeticum, Melampyrum sylvaticum* agg.
Constant species: *Potentilla erecta, Hypericum maculatum, Nardus stricta, Luzula luzuloides, Vaccinium myrtillus, Gentiana asclepiadea, Festuca rubra* agg., *Agrostis capillaris, Hypochaeris uniflora, Cruciata glabra*
Dominant species: *Nardus stricta, Festuca rubra* agg.

This association is delimited by pastures and meadows dominated by *Nardus stricta* and other oligotrophic grasses (*Festuca rubra* agg. and *Agrostis capillaris*) accompanied by the species typical of the east-Carpathian grasslands (Dacian migroelement) such as *Dianthus barbatus*, *Podospermum roseum*, *Viola dacica*. Besides these species, montane species of the *Nardo-Agrostion tenuis* alliance (*Hypochaeris uniflora*, *Arnica montana*, *Achillea distans* agg., *Poa chaixii*, *Gentiana clusii*, *Phyteuma spicatum*) and the species of forest margins (*Anemone nemorosa*, *Aposeris foetida* or *Polygonatum verticillatum*) are diagnostic. Oligotrophic grassland species (*Luzula luzuloides*, *Hypericum maculatum*, *Anthoxanthum odoratum*, *Cruciata glabra*, *Potentilla erecta*, *Gymnadenia conopsea*, *Polygala vulgaris*) are the most frequent. *Hypericum maculatum*, *Vaccinium myrtyllus* or *Calamagrostis arundinacea* become more abundant in unmanaged plots. The average number of species per plot is 38 (range 15–58). In the moss layer covering 1–95%, *Pleurozium schreberi*, *Rhytidiadelphus squarrosus*, *Hylocomnium splendens* and *Polytrichum formosum* are the most common species.

This vegetation includes extensive pastures and unfertilized meadows at higher altitudes (600–1400 m) distributed mainly on polonines. It was recorded only sporadically and is more abundant in the eastern part of our study area (in the Rakhivskyi, Mizhirskyi, Skolivskyi, Dolyn-

skyi, Verkhovinskyi districts) and on the Ukrainian border ridges with Slovakia and Poland. Some ot these grasslands are slightly grazed, but most are abandoned.

Cluster 17: *Antennario dioicae-Nardetum strictae* (54 relevés)
Author's original classification: *Antennario dioicae-Nardetum strictae* (4), *Calluno-Nardetum strictae* (5), *Hypochaerido uniflorae-Nardetum strictae* (2), *Leontodono autumnalis-Nardetum* (11), *Nardo-Festucetum rubrae* (1), *Violion caninae* (15), com. *Arnica montana-Nardus stricta* (4), com. *Festuca rubra* (1), com. *Nardus stricta-Trifolium pannonicum* (1), com. *Laserpitium alpinum-Agrostis tenuis* (1), not clear (9)

Diagnostic species: *Lycopodium clavatum, Calluna vulgaris, Arnica montana, Juniperus communis* (juv.), *Luzula pilosa, Gentianella amarella*
Constant species: *Potentilla erecta, Nardus stricta, Agrostis capillaris, Danthonia decumbens, Vaccinium myrtillus, Antennaria dioica, Thymus pulegioides, Polygala vulgaris, Hypericum maculatum, Anthoxanthum odoratum* agg., *Veronica officinalis, Achillea millefolium* agg.
Dominant species: *Nardus stricta*

An association characterized here by grasslands dominated by *Nardus stricta* or oligotrophic species such as *Potentilla erecta, Festuca rubra* agg. and *Pilosella officinarum*. Acidophilous dwarf-shrubs (*Vaccinium myrtillus, V. vitis-idaea* and *Calluna vulgaris*) together with oligotrophic herbs (*Antennaria dioica, Veronica officinalis*) and clubmoss *Lycopodium clavatum* are also characteristic for this association. Along with *Danthonia decumbens, Arnica montana* and *Luzula pilosa* these species are diagnostic. The species composition is formed by common mesotrophic grasses (*Agrostis capillaris, Anthoxanthum odoratum* agg., *Briza media*), species of the *Violion caninae* pastures (*Polygala vulgaris, Thymus pulegioides, Carex pallescens, C. pilulifera* and *Luzula campestris* agg.) and low-production meadows (*Centaurea jacea, Leucanthemum vulgare* agg., *Campatula patula*). The average species richness is 32 (range 13–54) species per plot and the moss layer is usually well developed (cover up to 95%). Along with the mosses (*Pleurozium schreberi, Dicranum bonjeanii, Rhytidiadelphus squarrosus, Polytrichum formosum, Hylocomnium splendens*), lichens of the *Cladonia* genus are frequent.

This vegetation includes extensive or short-term, abandoned pastures in the early stages of succession on relatively dry soils in the submontane to montane belts (600–1000 m) on slopes of various aspect. This association was the most frequently recorded in the Rakhivskyi, Dolynskyi and Verkhovinskyi districts.

Cluster 18: *Soldanello hungaricae-Nardetum strictae Kricsfalusy & Malynovski* 2000 (25 relevés), non-target vegetation
Author's original classification: *Festucetum rubrae* (8), *Hypochaerido uniflorae-Nardetum strictae* (1), *Soldanello hungaricae-Nardetum strictae* (15), not clear (1)

Diagnostic species: *Potentilla aurea, Pleurozium schreberi* (E_0), *Hylocomium splendens* (E_0), *Soldanella hungarica, Polytrichum juniperinum* (E_0), *Thymus pulcherrimus, Festuca picturata, Polytrichum commune* (E_0), *Campanula rotundifolia, Poa alpina, Cetraria islandica* (E_0), *Dicranum scoparium* (E_0), *Rhytidiadelphus triquetrus* (E_0), *Festuca ovina* subsp. *supina, Crocus heuffelianus, Vaccinium uliginosum, Carex canescens, Geum montanum, Carex sempervirens, Cladonia rangiferina* (E_0)
Constant species: *Potentilla aurea, Nardus stricta, Festuca rubra* agg., *Anthoxanthum odoratum* agg. (predominantly *A. alpinum*), *Agrostis capillaris, Vaccinium myrtillus, Potentilla erecta, Deschampsia cespitosa*
Dominant species: *Nardus stricta, Agrostis capillaris, Festuca rubra* agg.

This association is delimited by grasslands dominated by *Nardus stricta* and other oligotrophic grasses such as *Agrostis capillaris, Festuca rubra* agg., *Anthoxanthum odoratum* and *Deschampsia cespitosa*. Dwarf shrubs (*Vaccinium myrtillus, V. vitis-idaea*) with several species of the *Luzula* genus are admixed as well. The lower herb layer is rich in montane and subalpine species where *Potentilla aurea* is the most frequent species, usually accompanied by *Soldanella hungarica, Homogyne alpina, Antennaria dioica, Geum montanum* and *Crocus heuffelianus*. Further species of subalpine and alpine grasslands (*Festuca picturata, Cetraria islandica, Festuca ovina* subsp. *supina, Vaccinium uliginosum, Carex sempevirens*) are also admixed, forming a strong group of diagnostic species. Species richness of the herb layer is on average 20 vascular plant species in a 100 m^2 plot (range 8–36 species) and the moss layer consists usually of *Pleurozium schreberi, Hylocomium splendens, Rhytidiadelphus squarrosus, Polytrichum juniperinum* and *P. commune*.

It was recorded in the supramontane zone of the Eastern Carpathians at 1100–1492 m elevation (in the Rakhivskyi and Putilskyi districts and in the Borzhava Mts). Slopes were mostly mild (up to 20º) and south- or south-west-facing. Sporadically, this vegetation was found also on the north-facing slopes. These grasslands developed after removal of montane spruce and beech forests. However, they could also replace *Pinus mugo* and *Duschekia alnobetula* scrubs with well developed soils at altitudes up to 1600–1750 m (Kricsfalusy & Malynovski 2000).

Cluster 19: *Deschampsion caespitosae* community forming transitions to the *Arrhenatherion elatioris* and *Violion caninae* alliances (23 relevés), non-target vegetation
Author's original classification: *Agrostietum capillaris* (11), *Arrhenatherion elatioris* (3), *Calluno-Nardetum strictae* (1), *Nardetum strictae* (2), com. *Deschampsia caespitosa* (1), com. *Holcus mollis* (1), not clear (4)

Diagnostic species: *Vicia sepium, Holcus mollis, Cirsium palustre, Gnaphalium sylvaticum, Juncus effusus, Salix cinerea* (juv.), *Rubus idaeus* (juv.), *Hieracium laevigatum, Rumex alpinus*
Constant species: *Agrostis capillaris, Hypericum maculatum, Deschampsia cespitosa, Stellaria graminea, Rumex acetosa, Potentilla erecta, Achillea millefolium* agg., *Veronica chamaedrys, Galium mollugo* agg., *Campanula patula, Anthoxanthum odoratum* agg., *Plantago lanceolata, Cruciata glabra, Centaurea jacea, Vicia sepium, Vicia cracca, Nardus stricta, Holcus mollis, Carex pallescens, Angelica sylvestris*
Dominant species: *Hypericum maculatum, Agrostis capillaris, Deschampsia cespitosa, Holcus mollis*

This association contains meadows dominated by *Agrostis capillaris, Hypericum maculatum* and *Deschampsia cespitosa*, usually containing several hygrophilous species of moist and periodically inundated meadows (*Holcus mollis, Cirsium palustre, Juncus effusus, Scutellaria galericulata, Cirsium rivulare*), which suggest a transitional characteristic. There are 40 vascular plant species per 100 m^2 plot (range 17–62 species) on average. The moss layer is usually well developed with a variable total cover (1–80%).

These grasslands are distributed from submontane to montane belts at altitudes between 450 and 800 m, usually on gentle slopes (with inclination of 1–10°). Most stands are regularly mown and occasionally grazed after the first cut. They are more frequent only in the Bieszczady Mts on the Ukrainian-Polish border.

Discussion

In our study, we present the first formalized classification of semi-natural mesic grasslands in the Ukrainian Carpathians and adjacent areas. The majority of the analyzed phytosociological relevés were successfully assigned to syntaxa that are currently recognized in Ukraine and Slovakia. Habitat conditions and management regimes were well reflected in all currently used classification systems of mesic grasslands in temperate Europe (e.g. Oberdorfer 1983, Rodwell et al. 1992, Mucina et al. 1993, Chytrý et al. 2007, Matuszkiewicz 2001, Hegedüšová Vantarová & Škodová 2014). We finally delimited four well-differentiated alliances of target vegetation in the study area: i) meso-eutrophic hay meadows of the *Arrhenatherion elatioris* alliance; ii) intensive pastures of the *Cynosurion cristati* alliance; iii) oligotrophic low-productive pastures of the *Violion caninae* alliance; iv) oligotrophic montane grasslands of the *Nardo strictae-Agrostion tenuis* alliance and one questionable *Potentillo ternatae-Nardion strictae* alliance, recognized in the Romanian Carpathians and in the Balkan mountains (Velev & Apostolova 2009) with a floristic composition similar to the *Nardo strictae-Agrostion tenuis* alliance.

Methods of classification

Supervised classification methods are independent of the classified data set and therefore more applicable to different data sets over large areas than unsupervised methods (Rodríguez-Rojo et al. 2014). The semi-supervised methods were recommended by Tichý et al. (2014) as an alternative, which unlike the traditional unsupervised classification, preserves previously established vegetation units and, in addition, identifies new units in the unclassified parts of the data set. This method was also recommended for application of well established classification systems to new regions and used in several national and supranational classification studies (Rodríguez-Rojo et al. 2014, Slezák et al. 2014, Douda et al. 2016). In our study, we applied the revised classification elaborated for the territory of Slovakia for classification of grasslands including the Ukrainian Carpathians and adjacent areas of Slovakia, Poland and Hungary. One of the justifications for this approach was that in the adjacent parts of the Eastern Carpathian Mts, the vegetation has similar features independent of political borders. The formal definitions used in the expert system for identifying grassland syntaxa were primarily designed for the Slovak teritorry, therefore the additional expert revision of typical relevés used in the *a priori* groups was necessary prior to the semi-supervised analyses. Our experiences showed that higher floristic heterogeneity in the *a priori* groups results in higher heterogeneity within the clusters delimited by the analysis. Similarly, a higher number of relevés in the *a priori* groups supports the homogeneity of the final clusters. Therefore, the original *a priori* groups were extended by relevés assigned in the preliminary semi-supervised K-means analysis. Accordingly, identical vegetation types should be identified in the territory of all included countries, although some differences resulting from divergent land-use history could be expected. For 12 associations, continuous distribution in the Western and Eastern Carpathians was confirmed. On the other hand, the open nature of the applied approach enabled the identification of two additional associations (*Soldanello hungaricae-Nardetum strictae* and *Betonico officinalis-Trifolietum pan-nonici*). Again, based on our experiences, the semi-supervised classification has proved successful in a supranational classification. This method helps to correct discrepancies in classification systems of the

neighbouring countries sharing the same phytogeographic regions. In our study, such discrepancies were most obvious at the association level within the *Arrhenatherion elatioris* alliance and *Nardetalia strictae* order (Matuszkiewicz 2001, Solomakha 2008, Hegedüšová Vantarová & Škodová 2014).

Definition of clusters

Although 14 groups corresponding to associations were established prior to the analysis, only 12 were finally approved as well-delimited associations for the study region. This approval was based on a critical evaluation of the variability involved in each of the 19 finally recognized clusters and in a comparison of the diagnostic species differentiating these clusters. If the floristic differences among the particular clusters were not sufficient (too few species with fidelity over the given threshold) and the groups of relevés overlapped in the ordination plots and distribution maps, we then treated these clusters as lower syntaxa (variants) of one single association. This was the case of the *Alchemillo-Arrhenatheretum elatioris* defined as one of the *a priori* groups (cluster 3) and finally evaluated as a variant of the *Poo-Trisetetum flavescentis* association with transitional features towards the *Alchemillo-Arrhenatheretum elatioris*. Similarly, some of the newly-generated clusters were finally interpreted as variants of the *Poo-Trisetetum flavescentis* (clusters 2, 4 and 5) and as transitional grasslands (cluster 19).

In our study, we aimed at presenting the full overview of the variability of mesic semi-natural grassland vegetation in our study area. As our target vegetation is semi-natural (conditioned and regularly affected by human activities for decades or centuries), the delimitation of syntaxa is sometimes problematic and the vegetation often shares features of several different syntaxa (sometimes even of several different alliances). The classification is even more complicated due to inclusion of fallow vegetation, which develops on abandoned fields and recorded at different stages of abandonment. Considering these facts, we tried to keep our data set within a wide-ranging context, including also stands transitional to the non-target vegetation types. Only the clusters representing clear examples of non-target vegetation were excluded from the data set (e.g. relevés of the *Deschampsion cespitosae*), but clusters containing at least some relevés transitional to any of the target syntaxon were kept in the data set (e.g. cluster 18 containing mainly supramontane natural grasslands of the *Soldanello hungaricae-Nardetum strictae* originally ordered within *Potentillo ternatae-Nardion strictae* alliance, but also some transitions to the target *Nardo strictae-Agrostion tenuis* alliance).

The typical species composition of the *Pastinaco sativae-Arrhenatheretum elatioris* association adopted in the central and western Europe vegetation overviews (Ellmauer & Mucina 1993, Kučera 2007, Willner et al. 2013, Uhliarová et al. 2014) was not identified in our data set (cluster 1). Vegetation of older orchards and gardens, which are typical habitats of the *Pastinaco sativae-Arrhenatheretum elatioris* in central Europe, were classified mainly within the *Poo-Trisetetum flavescentis* or *Anthoxantho odorati-Agrostietum tenuis* associations in our study area. The stands of *Pastinaco sativae-Arrhenatheretum elatioris* were identified only from a few sites at lower altitudes. We speculate that the vegetation of this association gradually subsides towards the east of its distribution area, becoming sparse in the Ukrainian Carpathians. The association is mentioned also from Hungary (Borhidi et al. 2012) and Romania (Coldea et al. 2012). In Poland, similar grasslands were classified as the *Arrhenatheretum elatioris* (Matuszkiewicz 2001).

The association *Poo-Trisetetum flavescentis* is reported from Slovakia (Uhliarová et al. 2014), Czech Republic (Hájková et al. 2007), Romania (Coldea et al. 2012) and Austria (Ellmauer & Mucina 1993, here within the *Phyteumo-Trisetion* alliance). In Poland, there are similar grasslands classified within the *Gladiolo imbricati-Agrostietum capillaris typicum*. According to the syntaxonomic revisions by Rozbrojová et al. (2010) and Uhliarová et al. (2014), this association is identical with the *Poo-Trisetetum flavescentis*. Instead, we distinguished also several variants and transitions within a broad *Poo-Trisetetum flavescentis* (clusters 2, 3 and 5). Apart from Slovakia (Uhliarová et al. 2014), the *Alchemillo-Arrhenatheretum elatioris* association was not recognized in most European countries (Dierschke 1997, Kučera 2007, Ellmauer & Mucina 1993) as it represents a transition between the *Pastinaco sativae-Arrhenatheretum elatioris* distributed at lower altitudes and the *Poo-Trisetetum flavescentis* occurring at higher altitudes without numerous diagnostic species. Uhliarová et al. (2014) considered this community ecologically and floristically well-diferentiated by the presence of *Arrhenatherum elatius* and the absence of boreal species of the *Polygono bistortae-Trisetion flavescentis* alliance (*Arabidopsis halleri, Crepis mollis, Phyteuma spicatum*, *Primula elatior*). This concept was supported also in the large-scale study of Rozbrojová et al. (2010). In our data, we could not clearly distinguish this community from the *Poo-Trisetetum flavescentis* due to both, low number of diagnostic species, low frequency of *Arrhenatherum elatius* in the relevés of cluster 3 (set *a priori* as the *Alchemillo-Arrhenatheretum*) and low frequency of the *Polygono bistortae-Trisetion flavescentis* species in the relevés of typical variant of the *Poo-Trisetetum flavescentis* (cluster 4). In the Ukrainian Carpathians, *Arrhenatherum elatius* is rather rare, occurring mainly in the ruderal communities and frequently replaced by *Festuca rubra* agg. and *Schedonorus pratensis* in most semi-natural grasslands. Based on the aforementioned facts, we do not recommend accepting the *Alchemillo-Arrhenatheretum elatioris* as a separate association

in the Ukrainian Carpathians. Only future supranational classification studies will decide whether this vegetation type should be identified as a separate association.

The association *Anthoxantho odorati-Agrostietum tenuis* is known in the Carpathian territory from Slovakia (Uhliarová et al. 2014), the Czech Republic (Hájková et al. 2007) and Ukraine (Solomakha 2008). In the two last mentioned countries the association was included in the *Cynosurion cristati* alliance. It is also reported from Austria, but there it was ordered in the *Violion caninae* alliance (Willner et al. 2013). Similar grasslands recorded in Poland were classified within a broader *Arrhenatheretum elatioris* alliance (Matuszkiewicz 2001). In Hungary (Borhidi et al. 2012) and in Romania (Coldea et al. 2012), this association has not been recorded till now. In the Western Carpathians (Hájková et al. 2007, Krahulec et al. 2007, Uhliarová et al. 2014, Kliment & Ujházy 2014) there is no sharp border between the *Arrhenatherion elatioris* and *Violion caninae* alliances, and in particular, between the most oligotrophic association of the first one (*Anthoxatho odorati-Agrostietum tenuis*; cluster 6) and the most widespread unit of the second one (*Campanulo rotundifoliae-Dianthetum deltoidis*; cluster 13). Transitional stands occur in both clusters. In contrast to Czech and Slovak authors, Willner et al. (2013) suggested merging both units. However, these two associations of two different classes are sufficiently differentiated in the Eastern Carpathians, especially by a large group of eutrophic meadow species of the *Arrhenatheretalia* order (*Heracleum sphondylium*, *Taraxacum officinale*, *Phleum pratense*, *Galium mollugo*, *Lathyrus pratensis*, *Trisetum flavescens*, *Dactylis glomerata*) in the *Anthoxantho odorati-Agrostietum tenuis* and, in contrast, by a high frequency of *Nardetalia* species (*Nardus stricta, Calluna vulgaris*, *Vaccinium myrtillus*) and some oligotrophic woody species of unmown stands indicating low grazing intensity (*Betula pendula*, *Juniperus communis*, *Picea abies*, *Pinus sylvestris*) in *Campanulo rotundifoliae-Dianthetum deltoidis*.

The *Betonico officinalis-Trifolietum pannonici* association (cluster 7) represents species- rich meso-submontane grasslands with a typical east-Carpathian distribution. While the association was described as *Centaureo-Trifolietum pannonici* by Derzhypilsky et al. (2011) from the National park Hutschulschyna, this name cannot be accepted as valid according to the International Code of Phytosociological Nomenclature (ICPN, Weber et al. 2000), because it is unclear on which *Centaurea* species the epithet is based (§ 3g; two taxa *C. carpatica* and *C. pseudophrygia* are present in the nomenclatural type). We suggest the new name *Betonico officinalis-Trifolietum pannonici* for this association.

The distribution of the *Primulo veris-Agrostietum capillaris* (cluster 8) was finally confirmed only for the Slovak part of the Eastern Carpathians, where it occurs in the montane belt of the Vihorlat Mts (Ružičková & Michalko 1982, Uhliarová et al. 2014). The only relevé (No. 1044) from Ukraine (Chorney et al. 2005) is probably a transition to the *Festuco-Brometea* order. However, similar vegetation was reported from the Bukovinian Pre-Carpathians (Tokaryuk 2009) and from surrounding Chernivtsi (Roleček et al. 2014) outside our study area. The flysh bedrock and cooler, wet climate in the Ukrainian Carpathians do not support this community, described from the volcanic Vihorlat Mts (Ružičková & Michalko 1982).

Regarding the *Cynosurion cristati* alliance, we follow the syntaxonomic concept of Hájková et al. (2007) and Janišová et al. (2014) with two well-differentiated associations (*Plantagini majoris-Lolietum perennis* and *Lolio perennis-Cynosuretum cristati*) ordered in the *Cynosurion cristati* alliance. In Western Europe, eutrophilous pastures are often classified within two separate orders: the *Plantaginetalia majoris* Tüxen ex von Rochow 1951 and the *Trifolio repentis-Phleetalia pratensis* Passarge 1969 (Bardat et al. 2004). The *Plantagini majoris-Lolietum perennis* association (cluster 9) with higher abundance of trampling-tolerant species appears less frequently in the study area, a feature that might also be due to undersampling. This association is often published as *Lolietum perennis* (e.g. Janišová et al. 2014), but according to ICPN § 7 this name is not valid (Dengler et al. 2003). Outside Ukraine, this vegetation is widespread in similar habitats in the western and central part of Europe in the Czech Republic (Hájková et al. 2007), Slovakia (Janišová et al. 2014), Austria (Ellmauer & Mucina 1993) and Hungary (here classified within the *Potentillion anserinae* alliance, Borhidi et al. 2012). In syntaxonomic overviews of Poland (Matuszkiewicz 2001) and Romania (Coldea et al. 2012) the association was not mentioned, although its occurrence in these countries is highly probable. The vegetation of the *Lolio perennis-Cynosuretum cristati* (cluster 10) is very common in intensively grazed sites throughout the Carpathians (e.g. Ellmauer & Mucina 1993, Matuszkiewicz 2001, Hájková et al. 2007, Borhidi et al. 2012, Coldea et al. 2012, Janišová et al. 2014). Besides the *Lolio perennis-Cynosuretum cristati*, some other associations (*Festuco-Cynosuretum*, *Luzulo campestris-Cynosuretum cristati* and *Alchemillo-Cynosuretum*) were described for the vegetation of intensive pastures (cf. Janišová et al. 2014). We did not distinguish these communities, as they lack good diagnostic species, which was obvious also in our analyses.

In our study area, we identified four communities of the *Violion caninae* alliance described in Central Europe. In the Czech Republic (Krahulec et al. 2007) and Slovakia (Ujházy & Kliment 2014), the *Campanulo rotundifoliae-Dianthetum deltoidis* is considered a central association of the *Violion caninae* alliance. It is the most frequent association and lacks positive diagnostic species (see the discussion to the *Anthoxantho odorati-Agrostietum te-*

nuis). Its occurrence in the Eastern Carpathians has not been reported previously (Solomakha et al. 2008).

Thermophilous communities of the *Festuco rupicolae-Nardetum strictae* (cluster 11) are very rare in the Ukrainian Carpathians, inhabiting mainly semi-dry pastures at lower altitudes in contact with communities of the *Festuco-Brometea* class. In general, subxerophilous communities are rare in the studied area compared to the Western Carpathians due to a more humid climate in comparable sites. Species of the three classes (*Nardetea strictae*, *Festuco-Brometea* and *Molinio-Arrhenatheretea*) coexist in this vegetation, hence the classification is often problematic. The association is recognized only in Slovakia (Ujházy & Kliment 2014) and northern Hungary (Borhidi et al. 2012). Relationships and proper floristic delimitation from similar communities of Romanian Eastern Carpathians such as *Agrostio-Festucetum rupicolae* Csürös et Kaptalan 1964 (Chifu et al. 2008) are unclear and as yet remain unresolved. Semi-dry communities of warm sites in the southern Poland are classified within the *Carlino acaulis-Dianthetum deltoidis* Dubiel et al. 1999 association. This unit was reported also from the Bieszczady Mts. in the Eastern Carpathians (Zarzycki & Korzeniak 2013) and its relevés were included in our study. However, we could not confirm a separate position for this association using our semi-supervised approach. The syntaxonomic status of Carpathian subxerophilous associations of the *Violion caninae* alliance should be revised on the basis of a larger data set covering a broader geographical area.

The *Polygalo vulgaris-Nardetum strictae* is considered as the central association of the *Violion caninae* in Germany (Peppler-Liesbach & Petersen 2001) and Poland (Matuszkiewicz 2001). In the subcontinental regions of temperate Europe, the *Campanulo rotundifoliae-Dianthetum deltoidis* occupies the position of a central association. In contrast to Krahulec et al. (2007), we do not consider the suboceanic *Polygalo vulgaris-Nardetum strictae* with a broader range of moisture conditions as a synonym to the strictly mesophilic subcontinental *Campanulo rotundifoliae-Dianthetum deltoidis*. Similarly to the Slovak Carpathians, subhygrophilous communities of the Ukrainian Eastern Carpathians were ordered to the subassociation *Polygalo vulgaris-Nardetum strictae caricetosum fuscae* (cluster 12). It is a rare vegetation type throughout its whole distribution area because wet and semi-wet pastures dominated by *Nardus stricta* are generally not very common in the subcontinenal climatic region. Because these grasslands represent a transitional community between three classes: the *Nardetea strictae, Molinio-Arrhenatheretea* and *Scheuzerio-Caricetea fuscae,* their classification is not consistent in Europe. More oceanic communities from the (sub)atlantic north-western Europe (Pott 1995, Peppler-Liesbach & Petersen 2001), Poland (Matuszkiewicz 2001) to subcontinental Czech Republic (Krahulec et al. 2007) and Austria (Ellmauer 1993) were classified within the *Nardo-Juncion squarrosi* alliance. On the other hand, similar semi-wet *Nardus*-rich grasslands in Romania were classified within the *Molinion caeruleae* alliance (Doniţâ et al. 2005). Zarzycki & Korzeniak (2013) accepted the association *Nardo-Juncetum squarrosi* in the Bieszczady Mts as a vegetation type of the fringes of peatlands. The studied area is, however, outside the continuous distribution pattern of *Juncus squarrosus* (Meusel et al. 1965).

The *Hyperico maculati-Deschampsietum flexuosae* was included in *Campanulo rotundifoliae-Dianthetum deltoidis* as broadly understood by Krahulec et al. (2007), although Černý & Neuhäuslová (2006) supported the separation of these two well differentiated communities. Ujházy & Kliment (2014) also accepted this concept and reported the occurrence of the *Hyperico maculati-Deschampsietum flexuosae* from Slovakia. Due to differences in species composition and dominance, they ordered the West-Carpathian stands to a new subassociation *luzuletosum luzuloidis*. A variant with *Vaccinium myrtillus* of this subasociation was confirmed also from the Polish and the Ukrainian Eastern Carpathians in our study. The species composition of this vegetation in the Ukrainian Carpathians (cluster 14) is similar to the Slovak stands (Kliment & Ujházy 2014) except for the complete absence of *Avenella flexuosa*. The presence of numerous montane species demonstrates a proximity of the association to the *Nardo strictae-Agrostion tenuis* alliance, which occurs at higher altitudes. Along with the obligatory acidophytes, these montane species differentiate this association from the more thermophilous vegetation of the *Violion caninae* alliance (*Campanulo rotundifoliae-Dianthetum deltoidis, Festuco rupicolae-Nardetum strictae*).

The definitions of the three associations of the *Nardo strictae-Agrostion tenuis* alliance based on the Slovak data accord well with the corresponding vegetation of the Ukrainian Carpathians. Our approach revealed a broader distribution of both these associations and the alliance. While the formerly known distribution of this vegetation in the Northern Apennines (Gennai et al. 2014), Alps (Ellmauer 1993), Bohemian massif (Krahulec et al. 2007) and Western Carpathians (Kliment & Ujházy 2014) can be expanded to the Ukrainian part of the Eastern Carpathians, the south-eastern limits are as yet unknown. The south-Carpathian, Balkan *Potentillo ternatae-Nardion strictae* alliance was reported from Romania (Coldea et al. 2012), but its relationship to the *Nardo strictae-Agrostion tenuis* remains unclear. The first-mentioned alliance occurs at higher altitudes and is probably close to the alpine stands of the Ukrainian Carpathians. Velev & Apostolova (2009) emphasized a transitional position of the *Potentillo ternatae-Nardion strictae* alliance between the *Nardetalia strictae* order and the *Juncetea trifidi* class. Therefore, it would be considered a vicariant of the *Nardion strictae* alliance. However, as Chifu et al. (2006) reported the *Nardion strictae* alliance from the Romanian

Eastern Carpathians as well, a broader European synthesis is necessary to resolve this problem.

The *Betonico officinalis-Agrostietum capillaris* described by Blažková & Březina (2003) from the hay meadows of the Bukovské vrchy Mts close to the Ukrainian border near the Stuzhytsya village. In our study, it has been confirmed also for the Ukrainian territory and adjacent parts of Poland (Bieszczady) and can be expected also in the northern part of the Romanian Carpathians. This vegetation partly substitutes montane meadows of the Central European *Polygono bistortae-Trisetion flavescentis* alliance in the Eastern Carpathians.

The *Campanulo abietinae-Nardetum strictae* was originally described from the Bukovské vrchy Mts in Slovakia (Hadač et al. 1988), where it reaches the western border of its distribution linked to the Eastern Carpathian flora (Kliment & Ujházy 2014). In the neighbouring Polish part of the same ridge (Biesczady Wschódnie Mts), similar communities were classified as the *Nardetum carpaticum orientale* and later as the *Hypochaerido uniflorae-Nardetum strictae*. Kliment & Ujházy (2014) discussed the nomenclatural problems and proposed the name *Campanulo abietinae-Nardetum strictae* as being correct. However, grasslands with similar species composition to the two variants recognized in the Ukrainian Carpathians are known also from Romania (Coldea et al. 2012). The association *Scorzonero roseae-Festucetum nigrescentis* (Puşcaru et al. 1956) Coldea 1987 represents the more species-rich meadow variant and the association *Violo declinatae-Nardetum* Simon 1966 as the pasture variant. The geographical distribution and delimitation of these communities is not yet clear and additional research is needed to delimit these syntaxa.

The pastures of the *Antennario dioicae-Nardetum strictae* association (cluster 17) are well differentiated from the other vegetation types of the *Nardo strictae-Agrostion tenuis* alliance by the presence of numerous acidophilous species. Until now the association was accepted only in the Slovak syntaxonomic surveys (Mucina & Maglocký 1985, Kliment & Ujházy 2014). Similar communities in Poland are classified within the *Calluno-Nardetum strictae* Hrync. 1959 and *Leontodono autumnalis-Nardetum* Pałcz. 1962 associations. We anticipate the occurrence of similar vegetation in Romania.

The association *Soldanello hungaricae-Nardetum strictae* (cluster 18) was described by *Kricsfalusy & Malynovski* (2000), who argued that their material from extensive pastures at higher altitudes cannot be classified within any of the already described units. This view was supported also by our study and by comparisons with similar vegetation described from the Western Carpathians (e.g. *Phleo alpini-Nardetum*, Kliment & Ujházy 2014). However, relevés originally assigned to another association *Festucetum rubrae* Puşcaru et al. 1956 (classified also within the *Potentillo ternatae-Nardion strictae* alliance) were added to the cluster. It is obvious that the species composition of both associations overlaps in the Ukrainian territory. For their proper differentiation, the Romanian data should also be included.

Management

In the western part of the Ukrainian Carpathians, the *Poo-Trisetetum flavescentis* occurring especially on former arrable fields, is more frequent than the *Anthoxantho odorati-Agrostietum tenuis* (Škodová et al. 2015). Former kolkhozes (cooperatives) did not support traditional agronomical methods and thus were probably responsible for the retreat of many acidophytes that typify the *Anthoxantho odorati-Agrostietum tenuis* or *Campanulo rotundifoliae-Dianthetum deltoidis* associations. In the eastern part of the study area with well maintained traditional agriculture, the *Anthoxantho odorati-Agrostietum tenuis* is now much more frequent. The traditional mixed management involving the aftermath grazing of formerly mown grasslands regimes is frequently used in the Ukrainian Carpathians. It is probably responsible for a weaker floristic differentiation between traditional habitats of meadows and pastures compared to regions with separate effects of mowing and grazing. The transitional character of many grasslands situated among the *Arrhenatherion elatioris* meadows and the *Violion caninae* or *Nardo strictae-Agrostion tenuis* pastures was developed in many regions of the study area. Such grasslands are floristically heterogenous and were usually classified within the *Betonico officinalis-Agrostietum capillaris* (cluster 15). In the Western Carpathians, this association is very rare, extinct from most of the sites and recently documented only in the Bukovské vrchy Mts. Following abandonment this association is gradually transformed to the *Hyperico maculati-Deschampsietum flexuosae* (Kliment & Ujházy 2014). In our opinion, *Betonico officinalis-Agrostietum capillaris* has an ecological optimum in the territory of the Ukrainian Carpathians due to the well-preserved, mixed traditional management and its conservation there by traditional farming methods deserves strong priority.

Other syntaxa

In Supplement S7 we discuss the available information on syntaxa (in alphabetic order) which were used by the original authors of the relevés but were not approved as separate associations by our analyses. Most of the described syntaxa were published in the Ukrainian syn-taxonomic literature (reviewed in Solomakha et al. 2008) within the *Arrhenatheretalia* order and *Calluno-Ulicetea* class, or in other accessible phytosociological studies on grasslands within our study area (e.g. Solomakha et al. 2004, Chorney et al. 2005, Klimuk et al. 2006, Derzhypilsky et al. 2011).

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Authors contribution

MJ designed the study; MZ, LB, KD, MD, TF, MJ, RK, AK, JS, IŠ, PT, IT, EU and KU conducted the phytosociological sampling; MZ, MJ, IŠ and KU performed the statistical analyses and compiled the manuscript; MZ coordinated the manuscript compilation and all the authors commented on the manuscript.

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Electronic supplements

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Supplement S1. List of merged taxa.
Supplement S2. Unpublished relevés of *Molinio-Arrhenatheretea* class (rel. no. 1–250).
Supplement S3. Unpublished relevés of *Molinio-Arrhenatheretea* class (rel. no. 251–500).
Supplement S4. Unpublished relevés of *Nardetea strictae* class and non-target vegetation clusters.
Supplement S5. Header data of the unpublished relevés.
Supplement S6. List of taxa without specified ecological information in Didukh (2011).
Supplement S7. The syntaxa reported by the original authors of the relevés.
Supplement S8. Photographs of the studied associations.

Please download the electronic supplement and rename the file extension to .zip (For security reasons Adobe does not allow to embed .exe, .zip, .rar etc. files).

Appendix

Appendix 1: List of the analysed relevés used in numerical classification and their literature sources in a shortened form (author of the literature source, abbreviated reference, number of relevés).
They are ordered alphabetically within each cluster, while the unpublished relevés are mentioned first.

Cluster 1: Author's original unpublished material – 1 rel. (UA); Derzhypilsky et al. (2001) – 5 rels. (UA)

Cluster 2: Author's original unpublished material – 1 rel. (UA); Lengyel (unpublished) – 2 rels. (HU); Polish Vegetation Database (Kącki & Śliwiński 2012) – 30 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 4 rel. (SK)

Cluster 3: Author's original unpublished material – 15 rels. (UA); Chorney et al. (2005) – 1 rel. (UA); Derzhypilsky et al. (2001) – 1 rel. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 13 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 31 rels. (SK); Solomakha et al. (2004) – 2 rels. (UA); Škodová et al. (2015) – 1 rel. (UA)

Cluster 4: Author's original unpublished material – 36 rels. (UA); Pawłowski & Walas (1949) – 2 rels. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 7 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 7 rels. (SK); Škodová et al. (2015) – 2 rels. (UA); Zarzycki (2002) – 9 rels. (UA)

Cluster 5: Author's original unpublished material – 86 rels. (UA); Malynovski & Kricsfalusy (2002) – 1 rel. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 11 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 1 rel. (SK); Solomakha et al. (2004) – 1 rel. (UA)

Cluster 6: Author's original unpublished material – 55 rels.; Polish Vegetation Database (Kącki & Śliwiński 2012) – 18 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 28 rels. (SK); Škodová et al. (2015) – 12 rels. (UA); Zarzycki (2002) – 22 rels. (UA)

Cluster 7: Author's original unpublished material – 19 rels. (UA); Chorney et al. (2005) – 19 rels. (UA); Derzhypilsky et al. (2001) – 20 rels. (UA); Slovak Vegetation Database (Šibík 2012) – 1 rel. (SK); Solomakha et al. (2004) – 4 rels. (UA); Zarzycki (2002) – 1 rel. (UA)

Cluster 8: Chorney et al. (2005) – 1 rel. (UA); Slovak Vegetation Database (Šibík 2012) – 23 rels. (SK)

Cluster 9: Author's original unpublished material – 11 rels. (UA); Derzhypilsky et al. (2001) – 1 rel. (UA); Slovak Vegetation Database (Šibík 2012) – 1 rel. (SK); Solomakha et al. (2004) – 1 rel. (UA)

Cluster 10: Author's original unpublished material – 40 rels. (UA); Malynovski & Kricsfalusy (2002) – 1 rel. (UA); Slovak Vegetation Database (Šibík 2012) – 2 rels. (SK); Solomakha et al. (2004) – 3 rels. (UA); Škodová et al. (2015) – 5 rels. (UA); Zarzycki (2002) – 2 rels. (UA)

Cluster 11: Author's original unpublished material – 4 rels. (UA); Lengyel (unpublished) – 4 rels. (HU); Polish Vegetation Database (Kącki & Śliwiński 2012) – 3 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 11 rels. (SK); Škodová et al. (2015) – 1 rel. (UA)

Cluster 12: Author's original unpublished material – 14 rels. (UA); Lengyel (unpublished) – 1 rel. (HU); Polish Vegetation Database (Kącki & Śliwiński 2012) – 5 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 8 rels. (SK); Škodová et al. (2015) – 3 rels. (UA); Zarzycki (2002) – 1 rel. (UA)

Cluster 13: Author's original unpublished material – 49 rels. (UA); Chorney et al. (2005) – 1 rel. (UA); Derzhypilsky et al. (2001) – 1 rel. (UA); Klimuk et al. (2006) – 2 rels. (UA); Malynovski & Kricsfalusy (2002) – 1 rel. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 1 rel. (PL); Slovak Vegetation Database (Šibík 2012) – 8 rels. (SK); Škodová et al. (2015) – 7 rels. (UA); Zarzycki (2002) – 1 rel. (UA)

Cluster 14: Author's original unpublished material – 7 rels. (UA); Derzhypilsky et al. (2001) – 1 rel. (UA); Malynovski & Kricsfalusy (2002) – 1 rel. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 6 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 3 rels. (SK); Škodová et al. (2015) – 1 rel. (UA)

Cluster 15: Author's original unpublished material – 23 rels. (UA); Derzhypilsky et al. (2001) – 1 rel. (UA); Klimuk et al. (2006) – 3 rels. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 1 rel. (PL); Slovak Vegetation Database (Šibík 2012) – 1 rel. (SK); Solomakha et al. (2004) – 2 rels. (UA); Škodová et al. (2015) – 2 rels. (UA); Zarzycki (2002) – 5 rels. (UA)

Cluster 16: Author's original unpublished material – 7 rels. (UA); Derzhypilsky et al. (2001) – 3 rels. (UA); Klimuk et al. (2006) – 6 rels. (UA); Malynovski & Kricsfalusy (2002) – 1 rel. (UA); Pawłowski & Walas (1949) – 4 rels. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 20 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 26 rels. (SK); Solomakha et al. (2004) – 5 rels. (UA); Škodová et al. (2015) – 5 rels. (UA)

Cluster 17: Author's original unpublished material – 27 rels. (UA); Chorney et al. (2005) – 1 rel. (UA); Derzhypilsky et al. (2001) – 2 rels. (UA); Klimuk et al. (2006) – 1 rel. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 17 rels. (PL); Solomakha et al. (2004) – 5 rels. (UA); Škodová et al. (2015) – 1 rel. (UA)

Cluster 18: Author's original unpublished material – 1 rel. (UA); Malynovski & Kricsfalusy (2002) – 23 rels. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 1 rel. (PL)

Cluster 19: Author's original unpublished material – 2 rels. (UA); Polish Vegetation Database (Kącki & Śliwiński 2012) – 19 rels. (PL); Slovak Vegetation Database (Šibík 2012) – 1 rel. (SK); Solomakha et al. (2004) – 1 rel. (UA)

Appendix 2: Synoptic table with percentage frequency and modified fidelity index *phi* coefficient (19 columns).
Only species simultaneously showing i) *phi* ≥ 0.20; ii) significant occurrence in a particular cluster (Fisher's exact test $P < 0.001$) and iii) frequency ≥ 10% were included in the list of diagnostic species.
Only species with frequency ≥ 20% were included to "other species".

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Diagnostic species of *Pastinaco sativae-Arrhenatheretum elatioris* (cluster 1)																			
Geranium pratense	83 85	.-	8-	2-	4-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Rumex confertus	67 78	.-	.-	.-	4-	.-	2-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Lamium album	50 66	5-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Glechoma hederacea agg.	67 45	26 13	19-	17-	10-	4-	.-	.-	21-	11-	4-	3-	.-	.-	.-	4-	.-	.-	.-
Anthriscus sylvestris	67 65	5-	16 10	11-	.-	2-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Aegopodium podagraria	67 60	11-	3-	13 6	2-	1-	6-	.-	.-	.-	.-	.-	.-	.-	3-	3-	.-	.-	4-
Symphytum officinale	50 60	.-	9 7	.-	7 4	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Diagnostic species of *Poo-Trisetetum flavescentis*, thermophilous ruderal variant (cluster 2)																			
Cirsium arvense	17-	71 52	6-	3-	19 8	2-	.-	.-	21-	19-	4-	3-	.-	.-	.-	.-	.-	.-	.-
Poa pratensis agg.	17-	68 24	53 15	49 13	39 8	10-	11-	22-	29-	30-	52-	22-	1-	11-	11-	1-	4-	.-	35-
Daucus carota	.-	47 31	14-	8-	18-	13-	6-	.-	.-	23-	35-	9-	.-	.-	.-	.-	.-	.-	.-
Elytrigia repens	17-	45 31	23 12	10-	21 10	3-	2-	.-	7-	9-	4-	3-	.-	.-	.-	1-	.-	.-	17-
Rumex crispus	.-	45 49	2-	3-	3-	1-	2-	.-	.-	2-	.-	.-	.-	.-	.-	.-	2-	.-	17-
Torilis japonica	.-	34 57	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Cirsium vulgare	.-	34 39	.-	3-	7-	1-	.-	.-	7-	8-	.-	.-	1-	.-	.-	.-	2-	.-	4-
Mentha arvensis	.-	29 30	3-	2-	16 14	.-	.-	.-	.-	6-	4-	6-	.-	.-	.-	.-	.-	.-	9-
Centaurium erythraea	.-	32 27	2-	.-	11-	3-	3-	.-	7-	15-	13-	6-	4-	5-	.-	.-	2-	.-	.-
Potentilla reptans	.-	29 29	5-	5-	6-	4-	2-	.-	7-	17 14	4-	3-	.-	.-	.-	.-	.-	.-	.-
Carex muricata agg.	17-	26 33	2-	3-	3-	1-	.-	.-	.-	2-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Vicia tetrasperma	.-	24 43	.-	.-	2-	1-	.-	.-	.-	2-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Eurhynchium hians E0	.-	21 24	2-	5-	1-	6-	.-	.-	14-	.-	9-	.-	1-	.-	.-	.-	2-	.-	.-
Geranium columbinum	.-	21 40	.-	.-	.-	1-	.-	.-	.-	.-	4-	.-	.-	.-	.-	.-	.-	.-	.-
Origanum vulgare	.-	21 30	3-	.-	1-	2-	.-	.-	.-	.-	9-	6-	.-	.-	.-	.-	.-	.-	.-
Stachys palustris	.-	18 28	.-	.-	5-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	13-
Allium oleraceum	.-	16 31	2-	2-	.-	.-	.-	.-	.-	.-	4-	.-	.-	.-	.-	.-	.-	.-	.-
Artemisia vulgaris	.-	13 35	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Mentha longifolia	.-	13 24	.-	.-	5-	.-	2-	.-	.-	2-	.-	.-	.-	.-	.-	.-	.-	.-	4-
Brachythecium velutinum E0	.-	13 27	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	8-	.-
Oxalis stricta	.-	11 25	.-	.-	.-	2-	.-	.-	.-	4-	.-	.-	.-	.-	.-	.-	.-	.-	.-

Appendix 2: cont.

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Diagnostic species of *Poo-Trisetetum flavescentis*, transitions to *Alchemillo-Arrhenatheretum* (cluster 3)																			
Veronica chamaedrys	67 -	74 -	97 20	83 13	73 9	70 7	32 -	70 -	14 -	40 -	57 -	44 -	59 -	53 -	68 -	31 -	11 -	8 -	74 -
Diagnostic species of *Poo-Trisetetum flavescentis*, variant typicum (cluster 4)																			
Alchemilla sp. div.	33 -	21 -	64 -	90 22	65 10	66 10	40 -	4 -	57 -	49 -	17 -	66 -	42 -	21 -	58 -	23 -	28 -	24 -	57 -
Arabidopsis halleri	. -	. -	11 -	54 32	3 -	22 -	. -	. -	. -	. -	4 -	12 -	10 -	5 -	37 19	23 -	. -	8 -	22 -
Carum carvi	. -	8 -	17 -	54 29	34 15	13 -	6 -	. -	36 -	21 -	9 -	19 -	1 -	5 -	8 -	5 -	. -	. -	4 -
Crepis biennis	17 -	16 -	36 18	54 31	23 -	28 12	2 -	. -	. -	4 -	4 -	12 -	. -	11 -	3 -	1 -	4 -	. -	4 -
Trifolium dubium	. -	3 -	8 -	48 29	10 -	26 12	2 -	. -	7 -	23 -	22 -	19 -	11 -	. -	18 -	. -	. -	. -	. -
Bromus hordeaceus	. -	3 -	5 -	35 40	15 14	3 -	. -	. -	. -	8 -	. -	. -	. -	. -	. -	. -	. -	. -	. -
Poa trivialis	. -	8 -	11 -	33 35	2 -	2 -	. -	. -	7 -	. -	. -	6 -	1 -	. -	. -	. -	. -	. -	4 -
Rhinanthus alectorolophus	. -		5 -	29 29	19 17	14 -	2 -	. -	. -	2 -	. -	. -	1 -	. -	8 -	. -	. -	. -	. -
Atrichum undulatum E0	. -	5 -	3 -	27 21	. -	13 -	. -	. -	. -	15 -	4 -	22 -	. -	5 -	8 -	5 -	. -	4 -	. -
Veronica filiformis	. -	. -	5 -	25 32	1 -	1 -	. -	. -	14 -	2 -	. -	. -	. -	5 -	. -	. -	. -	. -	. -
Cirriphyllum piliferum E0	. -	3 -	. -	19 25	. -	7 -	. -	. -	. -	8 -	. -	. -	3 -	. -	8 -	1 -	. -	. -	. -
Diagnostic species of *Poo-Trisetetum flavescentis*, ruderal, nitrophilous variant (cluster 5)																			
Pimpinella major	. -	13 -	16 -	8 -	31 21	5 -	12 -	. -	. -	4 -	. -	9 -	1 -	5 -	8 -	9 -	4 -	. -	17 -
Crepis setosa	. -	. -	2 -	3 -	15 30	. -	2 -	. -	. -	. -	. -	. -	1 -	. -	. -	. -	. -	. -	. -
Galeopsis tetrahit	. -	. -	. -	2 -	13 27	. -	. -	. -	. -	2 -	. -	. -	4 -	. -	. -	. -	. -	. -	. -
Crepis capillaris	. -	. -	. -	. -	13 29	. -	. -	. -	. -	6 -	. -	. -	. -	. -	. -	. -	. -	. -	. -
Rumex thyrsiflorus	. -	. -	5 -	2 -	13 28	1 -	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -
Diagnostic species of *Anthoxantho odorati-Agrostietum tenuis* (cluster 6)																			
Sisyrinchium montanum	. -	. -	. -	5 -	8 -	24 21	**22 18**	. -	. -	4 -	. -	6 -	13 -	. -	11 -	. -	2 -	. -	. -
Diagnostic species of *Betonico officinalis-Trifolietum pannonici* (cluster 7)																			
Campanula glomerata agg.	. -	. -	20 -	25 -	14 -	34 11	52 24	35 -	. -	2 -	. -	19 -	6 -	. -	34 -	29 -	6 -	. -	26 -
Gladiolus imbricatus	. -	. -	. -	3 -	1 -	2 -	35 33	22 -	. -	. -	. -	12 -	. -	. -	13 -	. -	. -	. -	4 -
Ononis spinosa ssp. *hircina*	. -	. -	5 -	5 -	24 19	13 -	34 30	. -	7 -	2 -	4 -	3 -	7 -	. -	. -	. -	. -	. -	. -
Trifolium alpestre	. -	. -	3 -	. -	2 -	. -	32 47	. -	. -	. -	. -	. -	. -	. -	. -	1 -	6 -	. -	. -
Peucedanum oreoselinum	. -	. -	2 -	3 -	5 -	4 -	15 21	. -	. -	. -	. -	. -	3 -	. -	5 -	. -	. -	. -	4 -
Stellaria holostea	. -	. -	. -	. -	. -	. -	12 24	. -	. -	. -	. -	. -	. -	. -	3 -	5 -	2 -	. -	. -
Helianthemum canum	. -	. -	. -	. -	. -	. -	12 34	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -
Diagnostic species of *Primulo veris-Agrostietum capillaris* (cluster 8)																			
Cruciata glabra	33 -	21 -	64 -	73 -	68 -	81 12	69 -	100 21	7 -	21 -	57 -	81 -	77 -	47 -	87 14	62 -	46 -	. -	70 -
Briza media	. -	5 -	41 -	46 -	55 -	85 17	86 17	96 22	7 -	17 -	91 19	84 16	69 -	53 -	71 -	31 -	50 -	. -	43 -
Centaurea scabiosa	. -	5 -	3 -	2 -	1 -	4 -	. -	96 88	. -	. -	4 -	. -	1 -	. -	. -	. -	. -	. -	. -
Plantago media	. -	5 -	31 -	29 -	23 -	38 8	31 -	91 39	14 -	38 -	52 -	25 -	20 -	. -	5 -	5 -	6 -	4 -	9 -

Appendix 2: cont.

Cluster No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Primula veris	.	3	11	2	.	7	5	91 78	.	.	9	.	1	.	3	.	.	.	.
Brachypodium pinnatum	.	3	8	.	.	5	6	87 75	.	.	22	.	.	.	.	.	.	.	.
Dianthus carthusianorum agg.	.	3	.	.	.	5	8	87 78	.	2	13	.	1	.	.	1	.	.	.
Valeriana officinalis agg.	.	3	3	2	.	1	.	78 78	.	2	4	3	1	.	.	.	.	.	.
Trifolium rubens	.	.	3	.	.	1	.	74 83	.	.	.	.	.	.	.	.	.	.	.
Iris graminea	.	.	.	.	.	.	.	70 83	.	.	.	.	.	.	.	.	.	.	.
Tragopogon pratensis ssp. *orientalis*	.	8	22 13	6	.	10	5	65 53	.	2	17	.	.	.	.	.	.	.	.
Knautia arvensis	33	29	38	17	32	63 19	28	65 21	.	13	43	22	21	11	18	9	13	.	52
Silene nutans	.	3	2	2	.	7	5	61 55	.	2	17	3	.	.	3	4	4	.	.
Succisa pratensis	17	5	3	2	4	7	23	57 30	7	.	.	34 14	13	5	26	5	4	16	26
Arabis hirsuta agg.	.	.	2	2	.	1	.	52 69	.	.	.	.	.	.	.	.	.	.	.
Laserpitium latifolium	.	.	.	.	.	.	.	48 64	.	.	.	.	1	.	3	3	.	.	.
Ajuga genevensis	.	3	3	2	.	1	.	48 58	.	.	9	.	.	.	.	.	.	.	.
Thalictrum lucidum	17	.	.	.	.	.	2	48 54	.	.	4	3	.	.	.	.	.	.	.
Hieracium sabaudum	.	.	.	.	.	1	.	43 58	.	.	.	.	.	.	3	5	.	.	.
Campanula cervicaria	.	.	.	.	.	.	6	43 60	.	.	.	.	1	.	.	.	.	.	.
Euphrasia rostkoviana agg.	.	.	3	19	4	29 13	2	43 24	.	11	26	22	11	.	8	12	4	.	17
Carex montana	.	3	.	.	.	.	.	35 51	.	.	4	.	.	.	3	.	.	.	.
Campanula rapunculoides	.	3	5	5	3	9 7	.	30 35	7	2	.	3	.	.	.	.	.	.	.
Phleum phleoides	.	.	2	.	.	.	.	30 53	.	.	.	.	.	.	.	.	.	.	.
Vicia cassubica	.	.	.	.	.	1	.	30 53	.	.	.	.	.	.	.	.	.	.	.
Convallaria majalis	.	.	.	.	.	.	.	30 54	.	.	.	.	.	.	.	.	.	.	.
Dactylorhiza sambucina	.	.	.	.	1	1	.	30 44	.	.	9	3	.	.	.	.	.	.	.
Silene vulgaris	.	3	6	2	2	1	.	26 26	.	.	.	.	1	11	5	14 11	4	.	4
Anemone sylvestris	.	.	.	.	.	.	.	26 46	.	.	.	.	.	.	3	.	2	.	.
Anemone ranunculoides	.	.	.	.	.	.	.	26 43	.	.	.	3	.	.	3	3	.	.	.
Serratula tinctoria	.	.	2	.	.	.	2	26 36	.	.	9	6	.	.	3	.	.	.	.
Silene viscaria	.	.	2	.	.	4	.	22 38	.	.	.	.	1	.	.	1	.	.	.
Anacamptis morio	.	.	.	.	.	.	.	22 36	.	.	9	.	1	.	.	.	.	.	.
Viola odorata	.	.	.	.	.	1	.	22 44	.	.	.	.	.	.	.	.	.	.	.
Lilium martagon	.	.	.	.	.	1	.	17 30	.	.	.	.	.	.	.	10 16	.	.	.
Orchis mascula	.	.	.	.	.	.	.	13 35	.	.	.	.	.	.	.	.	.	.	.
Sedum sexangulare	.	.	.	.	.	1	.	13 29	.	.	4	.	.	.	.	.	.	.	.
Lathyrus niger	.	.	.	.	.	.	.	13 30	.	.	4	.	.	.	.	.	.	.	.
Mercurialis perennis	.	.	.	.	.	.	.	13 36	.	.	.	.	.	.	.	.	.	.	.

Appendix 2: cont.

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Diagnostic species of *Plantagini majoris-Lolietum perennis* (cluster 9)																			
Prunella vulgaris	17 -	53 -	33 -	81 12	67 -	72 8	46 -	70 -	100 22	89 16	30 -	78 -	77 11	21 -	79 -	25 -	33 -	12 -	39 -
Trifolium repens	50 -	37 -	75 -	94 19	74 10	78 12	35 -	. -	100 23	92 19	57 -	62 -	69 -	5 -	76 -	25 -	20 -	8 -	30 -
Plantago major	17 -	24 11	. -	10 -	9 -	1 -	2 -	. -	79 55	34 19	. -	6 -	1 -	. -	. -	. -	. -	. -	. -
Argentina anserina	. -	24 16	3 -	2 -	18 11	1 -	. -	. -	43 35	25 17	. -	9 -	. -	. -	. -	. -	. -	. -	. -
Polygonum aviculare agg.	. -	. -	. -	. -	. -	. -	. -	. -	14 37	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -
Matricaria discoidea	. -	3 -	. -	. -	. -	. -	. -	. -	14 34	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -
Diagnostic species of *Festuco rupicolae-Nardetum strictae* (cluster 11)																			
Ranunculus polyanthemos	. -	11 -	52 12	32 -	15 -	60 17	17 -	26 -	7 -	11 -	91 33	50 -	41 -	16 -	39 -	36 -	11	. -	13 -
Fragaria viridis	. -	. -	. -	. -	. -	4 -	. -	. -	. -	2 -	35 53	. -	. -	. -	. -	. -	. -	. -	. -
Festuca stricta ssp. *sulcata*	. -	. -	. -	3 -	. -	1 -	. -	9 -	. -	. -	26 37	. -	. -	. -	. -	. -	2 -	4 -	. -
Viola hirta	. -	3 -	5 -	. -	. -	8 9	. -	4 -	. -	. -	22 31	. -	. -	. -	. -	. -	. -	. -	. -
Polygala comosa	. -	. -	. -	. -	1 -	3 -	6 -	. -	. -	4 -	22 33	. -	1 -	. -	. -	. -	2 -	. -	. -
Avenula pubescens	. -	3 -	12 18	3 -	1 -	. -	. -	. -	. -	. -	17 26	. -	. -	. -	. -	. -	. -	. -	. -
Potentilla heptaphylla	. -	. -	. -	. -	. -	1 -	. -	9 -	. -	2 -	17 31	. -	. -	. -	. -	. -	. -	. -	. -
Diagnostic species of *Polygalo vulgaris-Nardetum strictae* (cluster 12)																			
Carex panicea	. -	5 -	3 -	8 -	18 -	25 -	18 -	9 -	7 -	9 -	43 -	88 41	38 11	21 -	18 -	1 -	31 -	. -	13 -
Silene flos-cuculi	17 -	37 -	36 12	48 19	29 -	15 -	3 -	. -	. -	2 -	17 -	53 23	6 -	11 -	24 -	3 -	. -	. -	17 -
Carex nigra	. -	. -	. -	3 -	1 -	1 -	. -	. -	. -	2 -	9 -	50 53	. -	. -	. -	1 -	2 -	. -	13 -
Carex flava agg.	. -	. -	. -	2 -	8 -	3 -	. -	. -	7 -	. -	. -	34 37	7 -	. -	. -	. -	4 -	. -	9 -
Climacium dendroides E0	. -	. -	3 -	19 -	. -	19 11	. -	. -	. -	11 -	9 -	31 22	15 -	. -	21 -	3 -	4 -	. -	. -
Juncus conglomeratus	. -	11 -	. -	. -	6 -	1 -	. -	. -	. -	2 -	4 -	28 34	1 -	. -	. -	. -	. -	. -	4 -
Dactylorhiza majalis	. -	3 -	2 -	. -	4 -	4 -	6 -	. -	. -	. -	4 -	22 22	1 -	. -	18 17	. -	2 -	. -	9 -
Carex flacca	. -	. -	. -	. -	7 11	1 -	. -	. -	. -	. -	. -	16 28	3 -	. -	. -	. -	. -	. -	. -
Agrostis canina	. -	. -	. -	. -	. -	. -	. -	. -	. -	. -	9 -	16 30	. -	. -	. -	. -	. -	. -	. -
Carex echinata	. -	. -	. -	. -	. -	1 -	. -	. -	. -	. -	. -	12 23	. -	. -	. -	. -	4 -	. -	9 -
Diagnostic species of *Campanulo rotundifoliae-Dianthetum deltoidis* (cluster 13)																			
Pilosella officinarum	. -	. -	. -	3 -	11 -	44 9	12 -	26 -	. -	53 14	48 -	28 -	89 33	42 -	50 -	21 -	54 14	12 -	9 -
Veronica officinalis	. -	3 -	8 -	14 -	13 -	34 -	6 -	35 -	7 -	51 -	35 -	28 -	72 20	68 -	42 -	34 -	61 14	56 -	43 -
Diagnostic species of *Hyperico maculati-Deschampsietum caespitosae* (cluster 14)																			
Hypericum maculatum	33 -	26 -	53 -	65 -	84 14	74 10	58 -	22 -	. -	21 -	22 -	41 -	61 -	100 22	87 16	83 14	63 -	12 -	91 -
Carex pilulifera	. -	. -	. -	11 -	2 -	37 5	. -	48 -	. -	6 -	26 -	53 14	49 12	79 29	37 -	34 -	59 18	36 -	13 -
Diagnostic species of *Betonico officinalis-Agrostietum capillaris* (cluster 15)																			
Centaurea phrygia agg.	17 -	3 -	17 -	41 13	43 14	28 -	34 -	. -	. -	9 -	. -	34 -	20 -	21 -	71 31	18 -	4 -	. -	. -

Appendix 2: cont.

Cluster No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Gymnadenia conopsea	.-	.-	3-	8-	12-	16-	42 13	52 19	.-	.-	9-	31-	21-	32-	63 26	53 19	19-	.-	13-
Rhytidiadelphus squarrosus E0	.-	3-	3-	49 17	4-	35 9	5-	.-	.-	21-	17-	34-	32-	21-	58 23	16-	11-	52 19	13-
Trollius altissimus	.-	.-	2-	11-	.-	4-	12-	.-	.-	.-	.-	6-	3-	.-	24 23	14 12	2-	.-	.-
Diagnostic species of *Campanulo abietinae-Nardetum strictae* (cluster 16)																			
Hypochaeris uniflora	.-	.-	2-	.-	.-	.-	2-	.-	.-	.-	.-	.-	1-	21-	3-	68 60	11-	12-	.-
Solidago virgaurea	.-	3-	3-	16-	10-	14-	9-	26-	7-	.-	17-	6-	15-	21-	37-	56 27	22-	.-	17-
Phyteuma spicatum	.-	.-	2-	3-	1-	4-	3-	.-	.-	.-	.-	.-	4-	5-	16-	36 39	2-	.-	.-
Achillea distans agg.	.-	.-	.-	3-	.-	.-	3-	.-	.-	.-	.-	.-	.-	16-	3-	36 44	.-	.-	.-
Podospermum roseum	.-	.-	6-	2-	.-	1-	.-	.-	.-	2-	.-	.-	3-	21-	21 15	32 27	6-	16-	.-
Hieracium lachenalii	.-	.-	.-	.-	.-	2-	.-	.-	.-	.-	.-	3-	3-	11-	11-	30 32	7-	.-	4-
Dianthus barbatus	.-	.-	.-	.-	1-	1-	.-	.-	.-	.-	4-	.-	6-	5-	3-	30 40	2-	.-	.-
Anemone nemorosa	.-	.-	3-	.-	.-	5-	2-	.-	.-	2-	.-	3-	3-	16-	13-	29 26	4-	12-	.-
Rumex alpestris	.-	.-	.-	3-	.-	1-	2-	.-	.-	.-	.-	3-	1-	21-	3-	25 25	2-	.-	17-
Hieracium umbellatum	.-	.-	-	.-	1-	1-	2-	.-	.-	.-	.-	6-	1-	.-	16-	21 22	13-	.-	4-
Thymus alpestris	.-	.-	.-	2-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	19 41	.-	.-	.-
Knautia dipsacifolia	.-	.-	3-	.-	1-	.-	3-	.-	.-	.-	.-	.-	.-	.-	5-	19 33	.-	.-	.-
Phleum rhaeticum	.-	.-	.-	3-	.-	.-	.-	.-	.-	.-	.-	.-	1-	.-	3-	17 24	.-	16-	.-
Melampyrum sylvaticum agg.	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	1-	.-	3-	14 29	4-	.-	.-
Diagnostic species of *Antennario dioicae-Nardetum strictae* (cluster 17)																			
Lycopodium clavatum	.-	.-	.-	2-	2-	1-	2-	.-	.-	6-	4-	.-	21 16	5-	3-	10-	50 46	.-	.-
Calluna vulgaris	.-	.-	2-	.-	.-	1-	2-	.-	.-	6-	.-	6-	14-	11-	8-	1-	48 45	.-	4-
Arnica montana	.-	.-	.-	3-	.-	5-	9-	.-	.-	.-	.-	3-	7-	16-	24-	27 17	37 26	12-	.-
Juniperus communis (juv.)	.-	3-	.-	3-	6-	6-	2-	.-	.-	21-	4-	16-	28 18	5-	3-	4-	31 22	4-	4-
Diagnostic species of *Soldanello montanae-Nardetum strictae* (cluster 18)																			
Potentilla aurea	.-	.-	2-	3-	.-	3-	.-	.-	.-	.-	.-	6-	3-	21-	16-	5-	13-	96 72	.-
Pleurozium schreberi E0	.-	3-	2-	6-	.-	11-	5-	.-	.-	13-	9-	16-	39 15	42-	42 16	27-	24-	60 28	4-
Hylocomium splendens E0	.-	.-	.-	5-	.-	13-	2-	.-	.-	4-	9-	19-	20-	16-	21-	10-	9-	56 37	.-
Soldanella hungarica	.-	.-	.-	.-	1-	.-	.-	.-	.-	.-	.-	.-	.-	5-	.-	.-	2-	56 69	.-
Polytrichum juniperinum E0	.-	.-	.-	.-	.-	.-	2-	.-	.-	.-	.-	.-	.-	5-	.-	9-	6-	44 51	4-
Thymus pulcherrimus	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	44 65	.-
Festuca picturata	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	1-	5-	.-	.-	.-	44 61	.-
Polytrichum commune E0	.-	.-	.-	.-	.-	.-	.-	.-	.-	2-	.-	3-	.-	16-	.-	18 15	2-	40 39	9-
Campanula rotundifolia	.-	.-	.-	.-	.-	4-	.-	4-	.-	.-	.-	.-	1-	5-	8-	.-	.-	24 33	.-
Poa alpina	.-	.-	.-	.-	1-	.-	.-	.-	.-	.-	.-	.-	1-	.-	.-	.-	.-	24 46	.-

Appendix 2: cont.

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Cetraria islandica E0	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	4^{-}	.$^{-}$	24^{44}	.$^{-}$
Dicranum scoparium E0	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	1^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	4^{-}	.$^{-}$	.$^{-}$	.$^{-}$	3^{-}	1^{-}	.$^{-}$	20^{36}	.$^{-}$
Rhytidiadelphus triquetrus E0	.$^{-}$	.$^{-}$	.$^{-}$	2^{-}	.$^{-}$	5^{-}	2^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	3^{-}	4^{-}	5^{-}	3^{-}	1^{-}	2^{-}	20^{27}	.$^{-}$
Festuca ovina ssp. *supina*	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	20^{44}	.$^{-}$
Crocus heuffelianus	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	1^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	1^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	16^{36}	.$^{-}$
Vaccinium uliginosum	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	16^{39}	.$^{-}$
Carex canescens	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	16^{39}	.$^{-}$
Geum montanum	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	12^{34}	.$^{-}$
Carex sempervirens	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	12^{34}	.$^{-}$
Cladonia rangiferina E0	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	12^{34}	.$^{-}$
Diagnostic species of *Deschampsion caespitosae* transitions to *Arrhenatherion elatioris* and *Violion caninae* (cluster 19)																			
Vicia sepium	67^{-}	37^{14}	31^{10}	21^{-}	32^{10}	7^{-}	5^{-}	9^{-}	.$^{-}$	.$^{-}$	.$^{-}$	6^{-}	.$^{-}$	.$^{-}$	11^{-}	4^{-}	2^{-}	.$^{-}$	61^{30}
Holcus mollis	17^{-}	8^{-}	2^{-}	10^{-}	12^{-}	3^{-}	9^{-}	.$^{-}$	.$^{-}$	4^{-}	.$^{-}$	3^{-}	3^{-}	.$^{-}$	5^{-}	6^{-}	9^{-}	.$^{-}$	61^{46}
Cirsium palustre	.$^{-}$	24^{16}	3^{-}	2^{-}	10^{-}	2^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	19^{-}	.$^{-}$	5^{-}	3^{-}	1^{-}	2^{-}	.$^{-}$	52^{44}
Gnaphalium sylvaticum	.$^{-}$	5^{-}	2^{-}	8^{-}	13^{-}	3^{-}	2^{-}	.$^{-}$	.$^{-}$	17^{-}	4^{-}	6^{-}	18^{-}	16^{-}	18^{-}	10^{-}	17^{-}	8^{-}	48^{29}
Juncus effusus	.$^{-}$	18^{10}	.$^{-}$	3^{-}	4^{-}	1^{-}	.$^{-}$	.$^{-}$	21^{-}	4^{-}	4^{-}	25^{16}	.$^{-}$	5^{-}	.$^{-}$	.$^{-}$	4^{-}	4^{-}	39^{30}
Salix cinerea (juv.)	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	5^{-}	3^{-}	3^{-}	2^{-}	.$^{-}$	22^{35}
Rubus idaeus (juv.)	.$^{-}$	3^{-}	2^{-}	.$^{-}$	.$^{-}$	.$^{-}$	2^{-}	.$^{-}$	.$^{-}$	2^{-}	.$^{-}$	.$^{-}$	4^{-}	.$^{-}$	3^{-}	9^{-}	2^{-}	.$^{-}$	26^{34}
Hieracium laevigatum	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	3^{-}	.$^{-}$	.$^{-}$	.$^{-}$	6^{10}	.$^{-}$	.$^{-}$	17^{31}
Rumex alpinus	.$^{-}$	.$^{-}$	.$^{-}$	2^{-}	1^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	4^{-}	.$^{-}$	.$^{-}$	1^{-}	.$^{-}$	.$^{-}$	3^{-}	.$^{-}$	.$^{-}$	17^{31}
Diagnostic species common for two associations																			
Arrhenatherum elatius	**100**^{56}	8^{-}	**72**^{37}	10^{-}	17^{-}	10^{-}	8^{-}	9^{-}	.$^{-}$	2^{-}	39^{15}	.$^{-}$	.$^{-}$	5^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	9^{-}
Heracleum sphondylium	**83**^{43}	21^{-}	36^{12}	**59**^{27}	19^{-}	24^{-}	20^{-}	13^{-}	.$^{-}$	4^{-}	.$^{-}$	.$^{-}$	1^{-}	.$^{-}$	11^{-}	16^{-}	.$^{-}$	.$^{-}$	4^{-}
Urtica dioica	**50**^{42}	**42**^{34}	2^{-}	2^{-}	2^{-}	.$^{-}$	3^{-}	.$^{-}$	7^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	11^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	4^{-}
Alopecurus pratensis	.$^{-}$	**32**^{27}	**28**^{23}	11^{-}	2^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	2^{-}	9^{-}	12^{-}	1^{-}	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	.$^{-}$	9^{-}
Galium mollugo agg.	17^{-}	**71**^{30}	44^{13}	19^{-}	49^{16}	28^{-}	.$^{-}$	.$^{-}$	.$^{-}$	23^{-}	26^{-}	19^{-}	1^{-}	5^{-}	3^{-}	1^{-}	6^{-}	.$^{-}$	**74**^{31}
Lathyrus pratensis	.$^{-}$	**61**^{26}	38^{12}	25^{-}	43^{15}	12^{-}	5^{-}	48^{18}	.$^{-}$	4^{-}	17^{-}	25^{-}	.$^{-}$	.$^{-}$	8^{-}	4^{-}	.$^{-}$	.$^{-}$	**52**^{21}
Clinopodium vulgare	.$^{-}$	**26**^{22}	5^{-}	2^{-}	5^{-}	7^{-}	6^{-}	**26**^{22}	.$^{-}$	.$^{-}$	4^{-}	3^{-}	.$^{-}$	5^{-}	3^{-}	.$^{-}$	2^{-}	.$^{-}$	4^{-}
Phleum pratense	.$^{-}$	**71**^{24}	48^{-}	41^{-}	**79**^{28}	34^{-}	20^{-}	13^{-}	21^{-}	38^{-}	17^{-}	31^{-}	7^{-}	16^{-}	16^{-}	.$^{-}$	2^{-}	.$^{-}$	43^{-}
Vicia cracca	50^{-}	**68**^{20}	56^{13}	43^{-}	**69**^{20}	44^{-}	29^{-}	9^{-}	7^{-}	23^{-}	17^{-}	31^{-}	14^{-}	.$^{-}$	26^{-}	6^{-}	4^{-}	.$^{-}$	61^{-}
Trisetum flavescens	17^{-}	18^{-}	**69**^{31}	**68**^{30}	23^{-}	35^{10}	9^{-}	4^{-}	.$^{-}$	15^{-}	39^{-}	12^{-}	7^{-}	5^{-}	3^{-}	3^{-}	.$^{-}$	.$^{-}$	22^{-}
Dactylis glomerata	67^{-}	82^{18}	**95**^{25}	**92**^{24}	70^{13}	60^{8}	49^{-}	61^{-}	7^{-}	43^{-}	52^{-}	19^{-}	15^{-}	5^{-}	16^{-}	21^{-}	4^{-}	.$^{-}$	48^{-}
Rumex acetosa	50^{-}	50^{-}	78^{14}	**94**^{21}	58^{-}	63^{6}	23^{-}	**96**^{22}	.$^{-}$	15^{-}	57^{-}	44^{-}	44^{-}	63^{-}	71^{-}	26^{-}	4^{-}	.$^{-}$	87^{18}
Cerastium fontanum agg.	17^{-}	37^{-}	48^{-}	**86**^{23}	70^{15}	49^{-}	8^{-}	17^{-}	71^{-}	**85**^{23}	52^{-}	50^{-}	45^{-}	11^{-}	29^{-}	9^{-}	17^{-}	28^{-}	.$^{-}$

Appendix 2: cont.

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Myosotis scorpioides agg.	.-	18-	25-	**48**^{23}	18-	27^{8}	3-	.-	.-	2-	.-	**56**^{29}	1-	.-	16-	14-	2-	.-	35-
Trifolium hybridum	.-	16-	8-	2-	**30**^{24}	1-	2-	.-	.-	2-	4-	3-	4-	.-	.-	1-	.-	.-	**39**^{33}
Polygala vulgaris	.-	3-	11-	33-	35-	**90**^{22}	55-	**100**^{27}	7-	25-	65-	66-	80^{17}	53-	71-	45-	63-	12-	13-
Pimpinella saxifraga agg.	.-	32-	56-	32-	34-	**87**^{23}	72^{16}	70-	.-	32-	**87**^{23}	34-	59-	.-	53-	6-	31-	.-	57-
Leontodon hispidus	33-	21-	44-	68^{13}	18-	**85**^{22}	35-	78^{18}	14-	49-	**83**^{21}	72^{15}	46-	16-	34-	23-	15-	.-	13-
Stachys officinalis	17-	11-	30-	25-	8-	49^{13}	**82**^{32}	**96**^{39}	.-	6-	26-	31-	14-	11-	39-	10-	2-	.-	4-
Trifolium pannonicum	.-	.-	3-	2-	.-	6-	**31**^{28}	**43**^{42}	.-	.-	.-	.-	1-	.-	5-	.-	2-	.-	.-
Astrantia major	.-	3-	9-	16-	4-	10-	**48**^{26}	**61**^{35}	.-	2-	.-	12-	6-	5-	24-	19-	9-	.-	4-
Carlina acaulis	.-	5-	12-	5-	2-	43^{10}	**68**^{25}	**91**^{38}	.-	.-	26-	3-	25-	26-	55^{17}	38-	37-	4-	.-
Campanula persicifolia	.-	.-	2-	3-	7-	7-	**34**^{24}	**57**^{44}	.-	.-	4-	3-	4-	5-	11-	1-	2-	.-	.-
Filipendula vulgaris	17-	24-	27-	11-	8-	19-	**52**^{23}	**91**^{49}	.-	.-	39-	6-	4-	.-	5-	.-	.-	.-	.-
Rhinanthus minor	17-	3-	36-	43-	27-	36-	**63**^{20}	**83**^{31}	.-	4-	30-	38-	14-	.-	45-	6-	11-	.-	26-
Agrimonia eupatoria	.-	**47**^{38}	6-	5-	4-	5-	2-	.-	.-	17-	**35**^{26}	6-	1-	.-	.-	.-	.-	.-	.-
Trifolium montanum	.-	3-	23-	.-	2-	27^{8}	37^{15}	**96**^{56}	.-	.-	**48**^{23}	16-	4-	.-	.-	3-	6-	.-	.-
Pilosella bauhinii	.-	.-	2-	.-	.-	8-	2-	**70**^{56}	.-	2-	**30**^{21}	6-	13-	5-	3-	.-	2-	.-	.-
Carex caryophyllea	.-	.-	3-	.-	.-	7-	.-	**35**^{34}	.-	.-	**30**^{29}	.-	3-	5-	.-	.-	6-	.-	.-
Euphorbia cyparissias	.-	11-	5-	3-	5-	10-	.-	**39**^{28}	.-	.-	**57**^{44}	3-	6-	.-	.-	.-	2-	.-	4-
Polygonatum verticillatum	.-	.-	2-	2-	.-	1-	.-	**52**^{49}	.-	.-	4-	.-	.-	.-	3-	**31**^{27}	6-	.-	.-
Tanacetum corymbosum	.-	.-	3-	2-	.-	1-	6-	**57**^{44}	.-	.-	4-	.-	.-	5-	13-	**44**^{33}	4-	.-	.-
Calamagrostis arundinacea	.-	3-	3-	.-	1-	.-	2-	**52**^{43}	.-	.-	.-	.-	.-	11-	3-	**32**^{25}	11-	8-	.-
Taraxacum sect. *Ruderalia*	.-	39-	66^{13}	**84**^{22}	70^{15}	43-	14-	39-	**100**^{30}	79^{19}	22-	22-	11-	5-	11-	8-	4-	.-	9-
Ranunculus repens	.-	**61**^{20}	23-	44^{11}	46^{12}	5-	5-	.-	**100**^{42}	40^{9}	.-	31-	4-	.-	8-	.-	2-	12-	43-
Medicago lupulina	17-	3-	9-	8-	**41**^{21}	10-	3-	.-	43-	**43**^{23}	4-	9-	14-	.-	5-	.-	9-	.-	4-
Lolium perenne	33-	5-	3-	8-	5-	1-	2-	.-	**100**^{63}	**64**^{37}	.-	6-	1-	.-	3-	.-	.-	.-	.-
Ochlopoa annua	.-	.-	.-	2-	1-	.-	.-	.-	**71**^{60}	**34**^{25}	.-	3-	1-	.-	.-	1-	.-	8-	9-
Bellis perennis	17-	.-	5-	21-	12-	1-	2-	.-	**100**^{59}	**68**^{37}	.-	19-	4-	.-	.-	.-	11-	.-	.-
Cynosurus cristatus	.-	24-	28-	70^{18}	47-	48-	35-	.-	**93**^{30}	**74**^{20}	26-	50-	39-	.-	29-	1-	6-	.-	43-
Scorzoneroides autumnalis	.-	8-	9-	13-	61^{19}	14-	32-	30-	**79**^{28}	**89**^{34}	30-	25-	37-	.-	5-	3-	31-	8-	13-
Danthonia decumbens	.-	.-	2-	2-	9-	40-	32-	30-	14-	28-	65^{19}	5 6-	**79**^{26}	53-	29-	16-	**78**^{25}	4-	.-
Luzula luzuloides	.-	.-	3-	3-	.-	8-	15-	52^{18}	.-	2-	.-	3-	10-	**63**^{24}	50^{16}	**82**^{35}	30-	52^{17}	26-
Pilosella aurantiaca	.-	.-	.-	14-	3-	8-	3-	.-	.-	.-	.-	12-	8-	11-	**45**^{29}	**34**^{20}	11-	12-	13-
Gentiana asclepiadea	.-	.-	3-	5-	5-	7-	45^{14}	.-	.-	.-	.-	16-	13-	42-	**63**^{25}	**78**^{34}	33-	20-	48-
Crepis conyzifolia	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	1-	5-	**21**^{22}	**38**^{43}	2-	.-	.-
Angelica sylvestris	.-	16-	11-	22-	8-	13-	15-	.-	.-	.-	4-	25-	3-	.-	**47**^{23}	27^{9}	6-	.-	**61**^{32}

Appendix 2: cont.

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Aposeris foetida	.	.	2	.	.	.	3	.	.	.	.	.	1	.	3	**22** ^{27}	.	**24** ^{29}	.
Homogyne alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	**27** ^{25}	19 ^{15}	**36** ^{35}	.
Viola dacica	.	.	2	2	.	1	.	.	.	.	.	.	1	5	3	**22** ^{22}	4	**32** ^{35}	.
Campanula serrata	.	.	.	5	1	1	22 ^{15}	.	.	.	.	3	.	5	3	**31** ^{25}	4	4	**35** ^{29}
Antennaria dioica	.	.	.	.	.	1	2	26	.	8	.	6	11	21	.	14	**70** ^{44}	**40** ^{21}	.
Cirsium rivulare	.	5	3	6	5	1	.	.	.	.	.	**38** ^{29}	1	.	.	.	.	.	**30** ^{22}
Deschampsia cespitosa	.	50	19	22	36	17	17	4	29	25	.	50	14	16	26	45 ^{8}	11	**68** ^{20}	**91** ^{32}
Diagnostic species common for several associations																			
Hypericum perforatum	.	**50** ^{23}	25	8	6	16	12	**65** ^{33}	.	9	**57** ^{27}	6	7	5	5	.	7	.	13
Galium verum agg.	.	21	27	17	13	42 ^{12}	**60** ^{23}	**87** ^{38}	7	21	**65** ^{26}	6	13	.	3	.	2	12	4
Viola canina	.	.	6	2	1	**68** ^{22}	6	**78** ^{27}	7	28	**87** ^{32}	47	**76** ^{26}	21	47	12	30	.	.
Thymus pulegioides	.	8	9	14	27	**86** ^{20}	60	83 ^{18}	.	42	**91** ^{23}	38	**93** ^{24}	42	79 ^{17}	35	67	.	48
Nardus stricta	.	.	5	3	13	40	40	30	7	38	43	**100** ^{25}	**94** ^{22}	**95** ^{22}	63	82 ^{16}	**100** ^{25}	**96** ^{23}	61
Vaccinium myrtillus	.	.	.	2	.	3	6	.	.	6	.	.	13	**79** ^{35}	32	**78** ^{35}	**74** ^{32}	**76** ^{34}	4
Vaccinium vitis-idaea	.	.	.	.	.	1	3	.	.	.	.	.	6	**47** ^{25}	13	**45** ^{24}	**56** ^{31}	**60** ^{34}	.
Poa chaixii	.	.	3	.	1	1	.	.	.	.	.	3	.	**42** ^{24}	13	**52** ^{32}	7	32 ^{16}	**43** ^{25}
Constant species																			
Achillea millefolium agg.	50	84	95 ^{9}	86	94 ^{9}	95 ^{9}	80	96	93	92	96	91	94	47	82	34	61	32	83
Anthoxanthum odoratum agg.	.	45	72	94 ^{11}	77	88 ^{8}	65	78	43	62	96	94	79	84	92	58	63	88	74
Leucanthemum vulgare agg.	50	37	73	87 ^{12}	81	94 ^{15}	86 ^{11}	100 ^{18}	21	57	78	66	80	42	84	35	43	.	57
Plantago lanceolata	83	63	84	92 ^{11}	84	93 ^{11}	85	91	79	83	74	88	90 ^{10}	37	82	23	37	.	70
Stellaria graminea	17	55	61	60	78 ^{14}	57	60	48	43	45	35	41	48	47	61	27	30	4	87 ^{18}
Festuca rubra agg.	.	74	56	84	22	95 ^{14}	58	78	14	74	83	88	69	89	87	77	59	88	48
Campanula patula	17	63	80	83 ^{14}	88 ^{16}	79 ^{12}	54	74	.	25	43	59	68	42	68	40	31	16	74
Lotus corniculatus	33	37	73	62	86 ^{15}	94 ^{18}	74	70	36	79	74	56	73	11	74	14	39	4	43
Ranunculus acris	83	68	80 ^{10}	90 ^{15}	67	73 ^{7}	43	65	57	70	65	88 ^{14}	56	16	55	30	19	16	52
Centaurea jacea	83	32	67	56	68	86 ^{15}	75 ^{10}	83	50	38	78	62	46	11	61	13	44	.	65
Trifolium pratense	100	26	66	94 ^{19}	76 ^{11}	75 ^{10}	43	91 ^{18}	50	77 ^{11}	74	41	56	5	68	29	9	.	22
Holcus lanatus	33	58 ^{16}	27	48	56 ^{15}	43	51 ^{12}	.	.	15	39	47	24	21	26	-	20	.	13
Schedonorus pratensis	17	68 ^{17}	73 ^{19}	60 ^{13}	71 ^{18}	57 ^{11}	18	22	14	26	48	59	20	16	21	3	.	.	43
Trifolium medium	.	29	19	25	54 ^{13}	57 ^{15}	42	.	14	19	35	56	49	16	34	17	35	.	39
Luzula campestris agg.	.	18	41	65	42	77 ^{14}	8	65	.	26	87 ^{19}	81 ^{16}	70 ^{11}	79	74	38	56	28	26
Carex pallescens	17	26	31	40	48	81 ^{15}	32	48	7	55	83	88 ^{17}	72 ^{10}	68	76	39	56	12	61
Agrostis capillaris	.	82	67	78	96 ^{9}	93	89	78	71	92	70	91	99 ^{10}	95	100	73	80	80	96

Appendix 2: cont.

Cluster No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No. of relevés	**6**	**38**	**64**	**63**	**100**	**134**	**65**	**23**	**14**	**53**	**23**	**32**	**71**	**19**	**38**	**77**	**54**	**25**	**23**
Potentilla erecta	.-	21-	39-	33-	39-	87[9]	85-	91-	14-	38-	87-	100[16]	93[13]	100[16]	92[12]	94[13]	100[16]	72-	87-
Other species																			
Vascular plants (E_1)																			
Hypochaeris radicata	.-	.-	6-	22-	22-	31[8]	12-	9-	14-	43[17]	35-	19-	27-	.-	18-	8-	26-	.-	22-
Equisetum arvense	.-	13-	20-	29-	34[12]	20-	18-	.-	14-	11-	22-	28-	11-	.-	13-	1-	7-	.-	39-
Platanthera bifolia	.-	.-	.-	11-	4-	19[7]	20-	22-	.-	.-	4-	34[19]	20-	21-	21-	.-	13-	.-	.-
Fragaria vesca	.-	8-	5-	11-	17-	22-	11-	17-	.-	23-	22-	6-	27-	.-	3-	9-	28-	8-	22-
Linum catharticum	.-	3-	3-	10-	17-	31[15]	15-	39-	7-	8-	30-	25-	13-	.-	3-	.-	.-	.-	.-
Cuscuta species	.-	3-	6-	21-	8-	34[21]	29[17]	.-	.-	9-	9-	9-	6-	.-	32-	.-	.-	.-	.-
Lysimachia nummularia	33-	24[12]	5-	24[12]	9-	5-	.-	.-	21-	9-	9-	12-	3-	.-	3-	3-	2-	.-	4-
Carex leporina	.-	13-	8-	11-	10-	1-	2-	.-	14-	11-	4-	25-	6-	11-	3-	8-	11-	32[16]	30-
Carex hirta	.-	29[14]	12-	6-	11-	15-	2-	13-	21-	9-	17-	16-	3-	.-	3-	.-	2-	.-	30-
Rumex acetosella	.-	8-	5-	8-	17-	13-	18-	9-	14-	21-	9-	.-	14-	16-	8-	4-	15-	8-	26-
Euphrasia species	.-	.-	2-	2-	19[10]	4-	15-	.-	21-	17-	4-	16-	24[14]	.-	5-	.-	13-	.-	.-
Anthyllis vulneraria	.-	.-	2-	3-	19[14]	14-	22[17]	26-	.-	.-	.-	6-	4-	.-	.-	.-	6-	.-	.-
Viola tricolor	.-	.-	14-	10-	22[14]	7-	11-	.-	14-	11-	4-	.-	1-	.-	3-	1-	2-	.-	26-
Ajuga reptans	.-	.-	8-	21-	3-	18[10]	5-	.-	.-	.-	9-	19-	8-	26-	5-	12-	.-	.-	.-
Equisetum sylvaticum	.-	3-	2-	2-	7-	2-	.-	.-	.-	.-	.-	9-	10-	.-	8-	1-	4-	.-	22-
Hypericum species	.-	.-	3-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	5-	.-	1-	.-	24[39]	.-
Festuca ovina	.-	3-	.-	.-	1-	6-	9-	.-	.-	.-	13-	6-	14-	11-	18-	18[11]	24[16]	.-	.-
Juncus tenuis	.-	18[15]	.-	3-	8-	.-	.-	.-	29-	11-	.-	6-	1-	5-	3-	.-	.-	.-	4-
Genista tinctoria	.-	.-	.-	.-	5-	6-	15[13]	22-	.-	.-	4-	3-	3-	5-	11-	1-	6-	.-	.-
Primula elatior	.-	5-	5-	22[20]	1-	4-	11-	.-	.-	.-	.-	12-	1-	.-	11-	14-	.-	.-	.-
Galium species	33[56]	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-
Erigeron annuus	33-	11-	11-	10-	14-	10-	3-	.-	.-	19-	9-	6-	1-	.-	.-	.-	.-	.-	.-
Trees and shrubs																			
Salix caprea (juv.)	.-	5-	2-	.-	3-	4-	9-	.-	.-	2-	4-	3-	8-	11-	13-	8-	20[15]	.-	13-
Sorbus aucuparia (juv.)	.-	.-	.-	.-	.-	1-	.-	.-	.-	.-	.-	.-	.-	.-	.-	21[30]	7-	8-	4-
Betula pendula (juv.)	.-	3-	.-	2-	4-	7-	5-	.-	.-	2-	.-	.-	10-	26-	13-	8-	19[12]	.-	13-
Bryophytes (E_0)																			
Thuidium delicatulum	.-	.-	6-	33[15]	.-	28[11]	.-	.-	7-	32[14]	4-	34-	25-	16-	29-	6-	2-	.-	.-
Plagiomnium affine	17-	3-	8-	22[13]	1-	20[11]	2-	.-	.-	8-	9-	6-	11-	11-	5-	5-	2-	4-	9-
Dicranum bonjeanii	.-	.-	.-	2-	.-	2-	.-	.-	.-	.-	.-	3-	17[15]	21-	13-	5-	15-	.-	.-