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# Diversity and classification of mountain grasslands of the alliance *Polygono-Trisetion* in Slovak Republic

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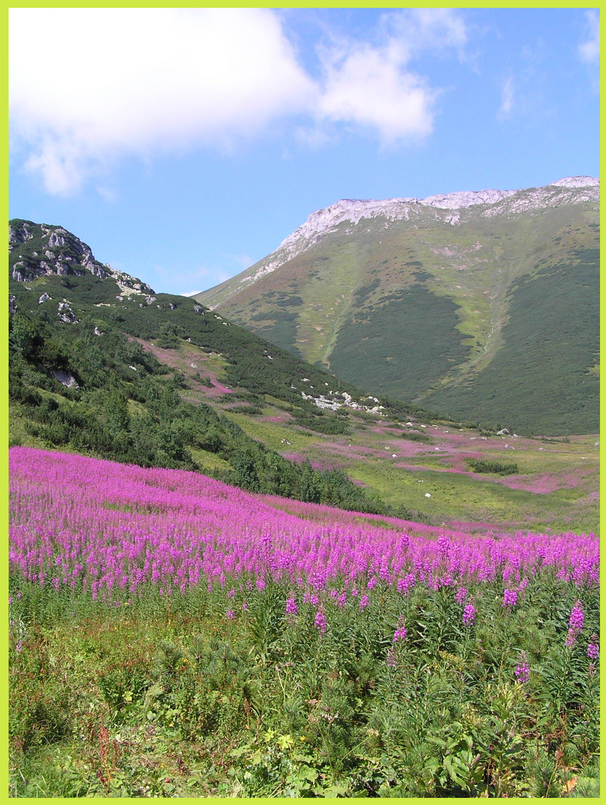
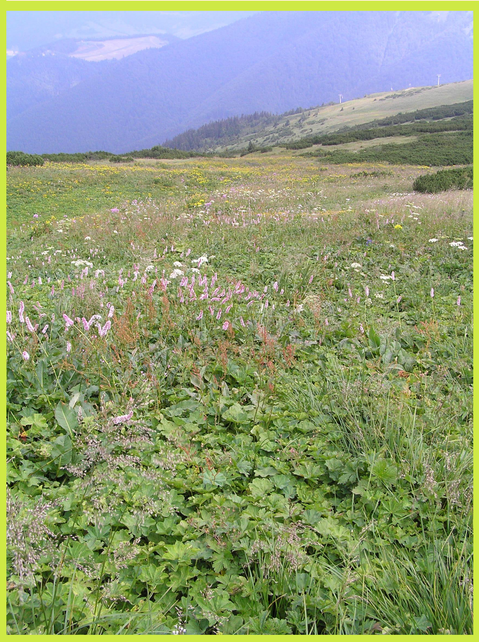
**Introduction**
The alliance includes mesophilous montane meadows distributed at altitudes ranging from 600 to 1500 m. Typical semi-natural grasslands dominated by medium-tall grasses (***Trisetum flavescens***, ***Agrostis capillaris***, ***Festuca rubra* agg.**) and broad-leaved herbs (***Geranium sylvaticum***, ***Alchemilla* spec. div.**, ***Crepis mollis***, ***Phyteuma spicatum***, ***Pimpinella major***) occur only in islands over calcareous bedrock on wetter and colder sites of saddles and slopes with mainly northern aspect, rarely on the non-carbonate substratum. Associations of this alliance have tight relationships to the alliances ***Arrhenatherion elatioris***, ***Bromion erecti*** and ***Nardo strictae-Agrostion tenuis***. The occurrence of following assotiations has been published from area of Slovakia:
*Agrostietum vulgaris* Syafer et al. 1927
*Alchemillo-Deschampietum caespitosae* Hadač et al. 1969
*Alchemillo-Festucetum pratensis* Hadač et al. 1969
*Geo-Dactylidetum slovenicae* Hadač 1981
*Geranio-Alchemilletum crinitae* Hadač et al. 1969
*Gladiolo-Agrostietum* (Br.-Bl. 1930) Pawłowski et Walas 1949
*Hyperico-Deschampsietum caespitosae* Hadač 1981
*Rhinantho-Alchemilletum monticolae* Hadač et al. 1969
*Campanulo glomeratae-Geranietum sylvatici* Ružičková 2002
*Crepido mollis-Agrostietum capillaris* Ružičková 2004

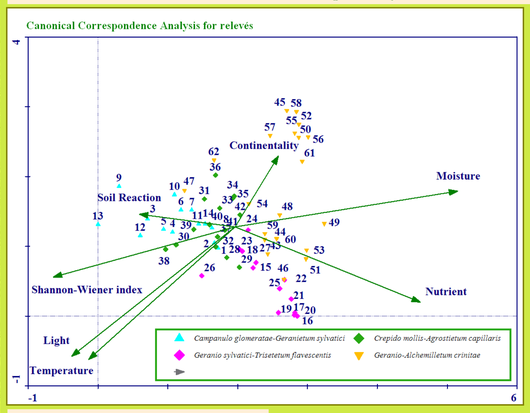
**Aim**
The aim was to revaluate the traditional approach to the classification mesophilous montane mesdows, classify it on the base of the contemporary classification methods and formalized techniques, which guarantees the increasing objectivity and expliciteness of results and define the diagnostic species for their identification.

**Methods**
The base for the study and evaluation of alliance *Polygono-Trisetion* was the Central Phytosociological Database of Slovakia (CDF, http://ibot.sav.sk/cdf/index.html, Hegedüšová 2007. Phytocoenological material (32 729 relevés) was stratified geographically in program JUICE (Tichý 2002). The stratified data set contained 16 640 phytosociological relevés belonging to all syntaxa recorded in Slovakia and stored in the CDF. Sociological species groups was generate by the COCKTAIL method (Bruelheide 2000). The degree of co-occurence has been calculated for each species using the *phi* coefficient of association (Chytrý et al. 2002). Sociological species groups together with dominance of important species have been used to formulate the definitions of associations using logical operators (Bruelheide 1997). Diagnostic, constant and dominant species in the synoptic table was calculated by JUICE software (Tichý 2002). Diagnostic species are orderd according to the value of *phi* coefficient, critical value of *phi* coefficient was set to 0.30. Constant species includes those species present in more than 40 % relevés ordered according to frequency. Dominant species are ordered according to percentage of relevés in which they reach the cover over 25 %. Detrended correspondent analysis (DCA) defined major gradients in the spatial arrangement of species of the analysed data set. Average Ellenberg indication values for relevés were plotted onto a DCA ordination diagram as supplementary environmental data.





**Results**
Based on the formal definitions four associations can be recognized within the alliance of *Polygono-Trisetion*: ***Campanulo glomeratae-Geranietum sylvatici, Geranio sylvatici-Trisetetum, Crepido mollis-Agrostietum capillaris, Geranio-Alchemilletum crinitae***.
The synoptic table pointed to differences in the floristic composition between the associations on the base of diagnostic, constant and dominant species. DCA analysis has shown that nutrient and moisture gradient exhibited the strongest positive correlation with first DCA axis. First axis also negatively correlated with soil reaction. Second axis positivly correlated with continentality.

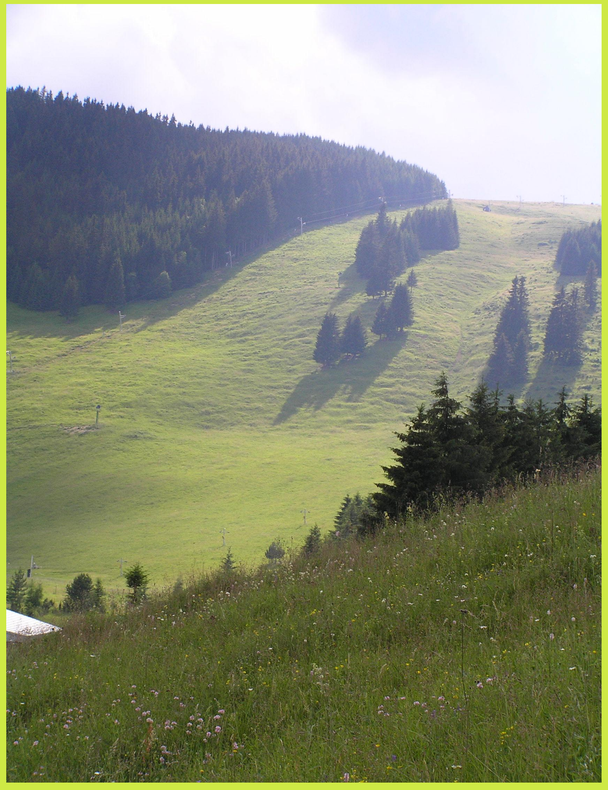



**Synoptic table with modified fidelity phi coefficient and percentage constancy**

| Group No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| No. of relevés | 14 | 13 | 15 | 20 |
| *Arrhenatherum elatius* | 91.9 93 | --- · | --- · | --- 5 |
| *Lilium bulbiferum* | 80.8 71 | --- · | --- · | --- · |
| *Campanula glomerata agg.* | 78.0 100 | --- · | --- 7 | --- 35 |
| *Silene vulgaris* | 71.0 71 | --- · | --- 13 | --- · |
| *Trifolium montanum* | 65.9 79 | --- · | --- 27 | --- 5 |
| *Potentilla heptaphylla* | 64.9 57 | --- · | --- 7 | --- · |
| *Tragopogon orientalis* | 63.3 93 | --- 8 | 8.7 47 | --- 10 |
| *Pyrethrum corymbosum* | 61.1 57 | --- · | --- 7 | --- 5 |
| *Linum catharticum* | 60.4 57 | --- 8 | --- · | --- 5 |
| *Sanguisorba minor* | 60.0 43 | --- · | --- · | --- · |
| *Cirsium erisithales* | 57.6 57 | --- · | --- 7 | --- 10 |
| *Polygala vulgaris* | 55.4 57 | --- · | 1.0 20 | --- · |
| *Acinos arvensis* | 54.2 36 | --- · | --- · | --- · |
| *Anthyllis vulneraria* | 53.9 64 | --- 8 | --- 20 | --- 5 |
| *Dianthus carthusianorum agg.* | 53.6 64 | --- · | --- 13 | --- 20 |
| *Aquilegia vulgaris* | 53.4 43 | --- · | --- 7 | --- · |
| *Knautia kitaibelii* | 53.4 43 | --- · | --- 7 | --- · |
| *Knautia arvensis agg.* | 53.1 64 | --- 8 | 2.7 27 | --- · |
| *Briza media* | 52.1 86 | --- 8 | 6.3 47 | --- 25 |
| *Colchicum autumnale* | 50.3 64 | --- · | 18.3 40 | --- · |
| *Viola hirta* | 48.0 29 | --- · | --- · | --- · |
| *Salvia pratensis* | 47.1 36 | --- · | --- 7 | --- · |
| *Leontodon hispidus* | 45.3 100 | 8.7 69 | --- 33 | --- 45 |
| *Jacea phrygia agg.* | 43.7 79 | --- · | 29.7 67 | --- 20 |
| *Silene nemoralis* | 42.0 29 | --- · | --- · | --- 5 |
| *Euphrasia rostkoviana agg.* | 41.2 21 | --- · | --- · | --- · |
| *Bromus monocladus* | 41.2 21 | --- · | --- · | --- · |
| *Campanula serrata* | 41.1 71 | --- · | --- 27 | 15.5 50 |
| *Viola tricolor* | 40.3 29 | --- · | --- 7 | --- · |
| *Lotus corniculatus agg.* | 36.5 86 | --- 46 | 6.7 60 | --- 25 |
| *Galium mollugo agg.* | 36.0 57 | 12.2 38 | --- · | --- 20 |
| *Fragaria vesca* | 35.6 36 | --- 8 | --- 13 | --- · |
| *Poa pratensis agg.* | 35.1 50 | --- 8 | 12.6 33 | --- 5 |
| *Arabis hirsuta agg.* | 34.4 21 | --- · | --- · | --- 5 |
| *Plantago media* | 34.4 50 | --- 8 | 20.9 40 | --- · |
| *Asarum europaeum* | 33.3 14 | --- · | --- · | --- · |
| *Medicago falcata* | 33.3 14 | --- · | --- · | --- · |
| *Trommsdorfia maculata* | 33.3 14 | --- · | --- · | --- · |
| *Salvia verticillata* | 33.3 14 | --- · | --- · | --- · |
| *Clinopodium vulgare* | 33.3 14 | --- · | --- · | --- · |
| *Anemone nemorosa* | 33.3 14 | --- · | --- · | --- · |
| *Pilosella bauhinii* | 33.3 14 | --- · | --- · | --- · |
| *Carduus glaucinus* | 33.3 14 | --- · | --- · | --- · |
| *Digitalis grandiflora* | 33.3 14 | --- · | --- · | --- · |
| *Origanum vulgare* | 33.3 14 | --- · | --- · | --- · |
| *Laserpitium latifolium* | 32.5 21 | --- · | --- 7 | --- · |
| *Achillea millefolium agg.* | 32.2 93 | --- 62 | --- 67 | --- 45 |
| *Ajuga reptans* | 32.0 36 | --- · | 17.6 27 | --- · |
| *Securigera varia* | 31.4 21 | --- 8 | --- · | --- · |
| *Plantago lanceolata* | 30.8 64 | --- 31 | 17.8 53 | --- 5 |
| *Prunella vulgaris* | 30.4 57 | 16.8 46 | --- 27 | --- · |
| *Galium pumilum agg.* | 30.2 29 | --- · | 2.9 13 | --- 5 |
| *Crepis biennis* | 2.2 36 | 80.6 100 | --- · | --- · |
| *Anthriscus sylvestris* | --- 7 | 77.5 85 | --- 7 | --- 5 |
| *Lychnis flos-cuculi* | --- · | 70.6 85 | --- 7 | --- 25 |
| *Myosotis scorpioides agg.* | --- · | 68.2 77 | --- · | --- 25 |
| *Bellis perennis* | --- · | 56.5 38 | --- · | --- · |
| *Taraxacum sect. Ruderalia* | --- 50 | 55.4 100 | 1.4 53 | --- 5 |
| *Alopecurus pratensis* | --- · | 52.6 77 | --- 13 | 13.7 45 |
| *Anthoxanthum odoratum agg.* | --- 50 | 46.7 100 | 7.4 67 | --- 25 |
| *Crocus discolor* | 12.1 43 | 44.5 69 | --- 20 | --- · |
| *Acetosa pratensis* | 9.3 71 | 43.6 100 | 11.6 73 | --- 10 |
| *Platanthera bifolia* | --- · | 42.9 23 | --- · | --- · |
| *Carum carvi* | --- 36 | 41.0 77 | --- 40 | --- 15 |
| *Phleum pratense* | --- 29 | 40.4 69 | --- 20 | --- 25 |
| *Cerastium holosteoides* | --- 29 | 39.8 69 | --- 27 | --- 20 |
| *Trifolium repens* | --- 50 | 39.6 92 | 9.6 67 | --- 25 |
| *Campanula patula* | --- 64 | 39.1 100 | 14.2 80 | --- 30 |
| *Heracleum sphondylium* | --- 50 | 37.5 92 | --- 40 | --- 60 |
| *Phyteuma spicatum* | --- 36 | 36.9 100 | 28.4 93 | --- 55 |
| *Cynosurus cristatus* | --- · | 36.4 31 | 4.3 13 | --- · |
| *Poa trivialis* | --- · | 35.4 46 | --- 13 | 5.5 25 |
| *Cardamine pratensis agg.* | --- 7 | 34.4 38 | --- · | 5.6 20 |
| *Ranunculus auricomus agg.* | --- 21 | 33.9 46 | --- 20 | --- · |
| *Ranunculus acris* | --- 71 | 32.3 100 | 23.2 93 | --- 40 |
| *Chaerophyllum aromaticum* | --- 7 | 31.5 38 | 3.6 20 | --- 5 |
| *Dactylis glomerata* | 20.5 93 | 30.5 100 | 2.5 80 | --- 40 |
| *Potentilla erecta* | --- 14 | --- 8 | 67.1 73 | --- · |
| *Poa chaixii* | --- 7 | --- · | 61.5 73 | --- 25 |
| *Luzula luzuloides* | --- 36 | --- 8 | 53.2 80 | --- 20 |
| *Pimpinella saxifraga agg.* | --- 14 | --- · | 50.5 47 | --- · |
| *Cardaminopsis halleri* | --- 21 | 11.2 54 | 49.3 87 | --- 15 |
| *Festuca rubra agg.* | --- 57 | --- 15 | 47.7 100 | 6.6 65 |
| *Ranunculus polyanthemos* | 17.2 43 | --- 8 | 47.4 67 | --- · |
| *Avenula pubescens* | 1.2 14 | --- · | 44.6 40 | --- · |
| *Trifolium medium agg.* | --- 7 | --- 8 | 44.1 40 | --- · |
| *Primula elatior* | 16.6 79 | --- 31 | 42.5 100 | --- 50 |
| *Trommsdorfia uniflora* | --- · | --- · | 41.8 33 | --- 10 |
| *Pilosella aurantiaca* | --- · | --- · | 40.1 27 | --- 5 |
| *Achillea distans agg.* | --- · | --- · | 39.7 20 | --- · |
| *Viola canina* | 4.2 14 | --- · | 38.2 33 | --- · |
| *Traunsteinera globosa* | --- 7 | --- · | 37.8 27 | --- · |
| *Crepis praemorsa* | --- · | --- · | 32.2 13 | --- · |
| *Dianthus deltoides* | --- · | --- · | 32.2 13 | --- · |
| *Cyanus mollis* | --- · | --- · | 32.2 13 | --- · |
| *Helianthemum nummularium agg.* | --- · | --- · | 32.2 13 | --- · |
| *Campanula persicifolia* | --- · | --- · | 32.2 13 | --- · |
| *Bistorta vivipara* | --- · | --- · | 32.2 13 | --- · |
| *Galium verum agg.* | --- · | --- · | 32.2 13 | --- · |
| *Botrychium lunaria* | --- · | --- · | 32.2 13 | --- · |
| *Acetosa arifolia* | --- · | --- · | --- 13 | 84.6 90 |
| *Senecio subalpinus* | --- · | --- 8 | --- 7 | 84.0 90 |
| *Deschampsia cespitosa* | --- · | --- 8 | 20.2 53 | 58.2 85 |
| *Bistorta major* | --- · | --- · | --- · | 57.7 40 |
| *Viola biflora* | --- · | --- · | --- · | 53.6 35 |
| *Rhinanthus pulcher* | --- · | --- · | --- · | 49.3 30 |
| *Ranunculus nemorosus* | --- · | --- · | --- · | 44.7 25 |
| *Luzula sylvatica* | --- · | --- · | --- · | 39.7 20 |
| *Agrostis stolonifera s.lat.* | --- · | --- · | --- · | 39.7 20 |
| *Homogyne alpina* | --- · | --- · | --- · | 39.7 20 |
| *Trollius altissimus* | --- · | --- · | 15.5 27 | 36.1 40 |
| *Thymus alpestris* | --- · | --- · | --- · | 34.2 15 |
| *Ligusticum mutellina* | --- · | --- · | --- · | 34.2 15 |
| *Vaccinium myrtillus* | --- · | --- · | --- · | 34.2 15 |
| *Soldanella carpatica* | --- · | --- · | --- · | 34.2 15 |
| *Astrantia major* | 9.0 21 | --- · | --- 7 | 30.5 35 |
| *Chaerophyllum hirsutum* | --- · | --- 15 | --- 13 | 30.1 35 |

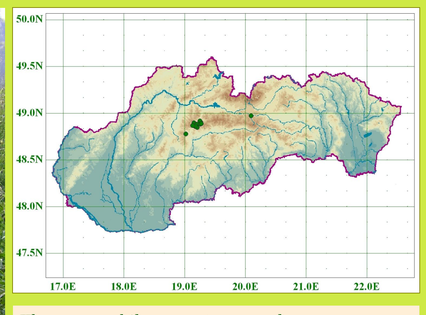
**Sociological species groups:**

**Agrostis capillaris:** *Anthoxanthum odoratum* agg., *Festuca rubra* agg., *Agrostis capillaris*
**Arrhenatherum elatius:** *Arrhenatherum elatius, Tragopogon orientalis, Galium mollugo* agg.
**Campanula glomerata:** *Campanula glomerata* agg., *Aquilegia vulgaris, Lilium bulbiferum*
***Cardaminopsis halleri:*** *Cardaminopsis halleri, Crocus discolor, Primula elatior*
***Festuca carpatica:*** *Saxifraga rotundifolia, Corthusa matthioli, Festuca carpatica, Adenostyles alliariae*
***Geranium sylvaticum:*** *Geranium sylvaticum, Crepis mollis, Phyteuma spicatum*
***Heracleum sphondylium:*** *Heracleum sphondylium, Crepis biennis, Anthriscus sylvestris, Chaerophyllum aromaticum, Geranium pratense*
***Trisetum flavescens:*** *Dactylis glomerata, Taraxacum sect. Ruderalia, Trisetum flavescens*
***Pimpinella major:*** *Pimpinella major, Knautia maxima, Pyrethrum clusii*
**Poa alpina:** *Poa alpina, Phleum rhaeticum, Ligusticum mutellina*
**Scabiosa lucida:** *Scabiosa lucida, Phyteuma orbiculare, Thesium alpinum, Carduus glaucinus*
**Senecio subalpinus:** *Senecio subalpinus, Viola biflora, Acetosa arifolia*
**Viola canina:** *Viola canina, Polygala vulgaris, Luzula campestris* s.lat.



## *Campanulo glomeratae-Geranietum sylvatici* Ružičková 2002

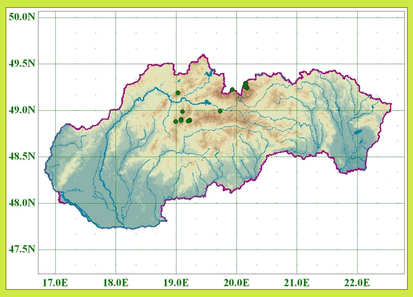
**Formal defintion (14 relevés):**
((<### Geranium sylvaticum>OR<Geranium sylvaticumUP05>)AND<### Campanula glomerata>)NOT(<Sanguisorba officinalisUP05>OR<Festuca rupicolaUP05>)




These mesophilous montane meadows are very species-rich with a large group of calcareous rather thermophilous species. Numerous rare and endangered species occur here as well. This vegetation grows on mineral-rich soils on carbonate substratum at altitudes ranging from 600 to 1100 m. The centers of its distribution are Starohorské vrchy Mts., the south-eastern part of Veľká Fatra Mts. and Nízke Tatry Mts. It is considered to be a relic of the semi-intensive traditional agriculture in this region.

## *Geranio-Alchemilletum crinitae* Hadač et al. 1969

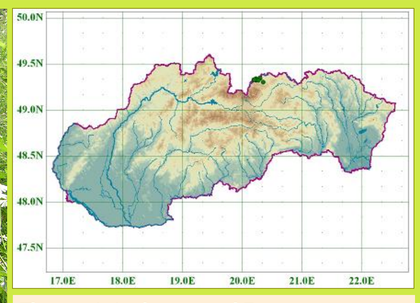
**Formal defintion (20 relevés):**
((<### Geranium sylvaticum>AND<Alchemilla vulgaris s. lat.UP05>)AND((<### Pimpinella major>OR<Bistorta majorUP05>)OR<### Senecio subalpinus>))NOT((((<### Festuca carpatica>OR<Festuca carpaticaUP05>)OR(<### Poa alpina>OR<### Viola canina>))OR(<### Arrhenatherum elatius>OR<### Cardaminopsis halleri>))OR<### Scabiosa lucida>)




These chionophilous montane meadows occur at higher altitudes with a long-lasting snow cover. They contain some species of higher altitudes such as *Acetosa arifolia, Campanula serrata, Potentilla aurea, Senecio subalpinus* and *Viola biflora*. Most localities have been recorded in the Veľká Fatra, Malá Fatra, Nízke Tatry, Západné Tatry and Belianske Tatry Mts. Most of these localities are recently abandoned and it is necessary to ensure their traditional utilization to maintain their diversity.

## *Geranio sylvatici-Trisetetum flavescentis* Knapp ex Oberd. 1957

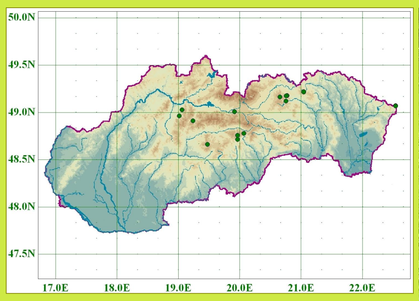
**Formal defintion (13 relevés):**
((<### Geranium sylvaticum>AND<### Trisetum flavescens>)AND(<### Heracleum sphondylium>AND<### Agrostis capillaris>))NOT<### Arrhenatherum elatius>




The association has a central European distribution. In Slovakia, its occurrence is conditioned by a specific local climate, long-term inversions and impermeable nutrient-rich soils. It was recorded in Spišská Magura Mts. and in the northern part of the Veľká Fatra Mts. in the vicinity of villages at altitudes from 700 to 900 m. A historical grassland use is still kept there involving manuring and mowing twice a year.

## *Crepido mollis-Agrostietum capillaris* Ružičková 2004

**Formal defintion (15 relevés):**
((<### Geranium sylvaticum>AND<### Agrostis capillaris>)AND<### Cardaminopsis halleri>)NOT((<Trisetum flavescensUP05>OR<### Arrhenatherum elatius>)OR(<### Poa alpina>OR< Nardus strictaUP05>))




These semi-natural meadows rich in species of the *Arrhenatherion elatioris* are common on cool and humid sites at altitudes between 700–1200 m in the Nízke Tatry, Muránska planina, Levočské vrchy, Veľká Fatra, Bukovské vrchy, Slovenský raj., Poľana and Čergov Mts. The original species composition is kept only if they are regularly mown or grazed and occasionally fertilized.

**Conclusion**
The results of the DCA analysis demonstrated that the most strong effect on the data set variability was predominantly produced by nutrient, moisture and soil reaction. Light and temperature did not show significant effect. The most basiphilous soils occupy *Campanulo glomeratae-Geranietum sylvatici, Geranio sylvatici-Trisetetum flavescentis* is ocurred on the most nutrient-rich soils and *Geranio-Alchemilletum crinitae* on the coldest localities at the highest altitudes. *Crepido mollis-Agrostietum capillaris* has intermediate character betweet other associations. Recenty, most of these meadows remain unmown and they are seriously endangered by succession, afforestation or by conversion to downhill courses.

**Aknowledgement**
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