Hacquetia 21/1 • 2022, 107–151 DOI: 10.2478/hacq-2021-0024 sciendo

# Natural calcareous Norway spruce woodlands in Slovakia and their syntaxonomical classification

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**Key words:** *Athyrio-Piceetalia*, calcareous woodlands, forest plant communities, nomenclature, *Picea abies*, phytocoenology, supramontane woodland, syntaxonomy, *Vaccinio-Piceetea*, Western Carpathians.

**Ključne besede:** *Athyrio-Piceetalia*, gozdovi na karbonatih, gozdne rastlinske združbe, nomenklatura, *Picea abies*, fitocenologija, supramontanski gozdovi, sintaksonomija, *Vaccinio-Piceetea*, Zahodni Karpati.

**Abstract**

A second version of the syntaxonomical classification of calcareous Norway spruce communities is presented for the region of Slovak Western Carpathians. Recent knowledge on delimitation of natural Norway spruce woodlands in Slovakia is summarized as well. As result, four in Slovakia traditionally recognized associations are distinguished: *Seslerio caeruleae-Piceetum* on the ecologically most extreme habitats, followed by *Cirsio erisithalis-Piceetum* (a replacement for pseudonymically used *Cortuso matthioli-Piceetum*), tall-forb community of *Adenostylo alliariae-Piceetum* and ca. species-poor low-forb community of *Mnio spinosi-Piceetum* (syn. *Oxalido-Piceetum*). Additionally, two new associations are differentiated: *Fragario vescae-Piceetum* ass. prov. standing between *Cirsio-Piceetum* and *Adenostylo-Piceetum* and acidified *Hieracio murorum-Piceetum* on deeper soils developed over rocks of the Mráznica formation. For nomenclatural reasons, new order *Cortuso-Piceetalia* is described for species-rich calcicolous communities of the class *Vaccinio-Piceetea* as well as subordinated new alliance *Cortuso matthioli-Piceion* for the supramontane calcicolous Norway spruce communities.

**Izvleček**

V članku predstavljamo drugo verzijo sintaksonomske klasifikacije smrekovih združb na karbonatu na območju Zahodnih Karpatov Slovaške, povzeli pa smo tudi trenutno poznavanje razmejitve naravnih smrekovih gozdov na Slovaškem. Rezultat so štiri tradicionalno prepoznane asociacije: *Seslerio caeruleae-Piceetum* na ekološko najbolj ekstremnih rastiščih, sledi *Cirsio erisithalis-Piceetum* (ki nadomešča psevdonim *Cortuso matthioli-Piceetum*), *Adenostylo alliariae-Piceetum* in vrstno siromašna asociacija z nizkimi zelišči *Mnio spinosi-Piceetum* (sin. *Oxalido-Piceetum*). Dodatno smo ločili dve novi asociaciji: *Fragario vescae-Piceetum* ass. prov., ki predstvalja vmesno asociacijo med *Cirsio-Piceetum* in *Adenostylo-Piceetum*, ter zakisano asociacijo *Hieracio murorum-Piceetum* na globljih tleh, razvitih na skalah formacije Mráznica. Zaradi nomenklaturnih razlogov smo opisali nov red *Cortuso-Piceetalia* za vrstno bogate združbe na karbonatih znotraj razreda *Vaccinio-Piceetea* in znotraj reda novo zvezo *Cortuso matthioli-Piceion*, kamor uvrščamo supramontanske smrekove združbe na karbonatih.

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Received: 31. 3. 2021
Accepted: 13. 10. 2021

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# Introduction

Syntaxonomical classification of the Norway spruce communities has undergone a long way since the establishment of the class *Vaccinio-Piceetea* by Braun-Blanquet et al. (1939). Hadač (1962) published a groundbreaking proposal for a fundamental division of this class based on floristical and ecological differentiation valid on supraregional to continental scale: separation of (1) usually species-poor communities growing on (very) strongly acidic soils, i.e. distributed over non-carbonate rocks and (2) species-rich communities growing on moderately to slightly acidic and neutral soils, i.e. inhabiting areas of various carbonate rocks. For these basic units the rank of order was assigned: the order *Myrtillo-Piceetalia* Hadač 1962 for the first group (the correct order name is *Piceetalia abietis* Pawłowski ex Pawłowski et al. 1928) and the order *Athyrio-Piceetalia* Hadač 1962 for the second group (for nomenclatural discussion see Kučera, in red.).

Acceptance of this syntaxonomical division is continuously growing in the European countries (for detail see Kučera, in red.), and even if authors did not recognize the order *Athyrio-Piceetalia* Hadač 1962 as a separate unit of the rank of order, their syntaxonomical system reproduced the respective two-component fundamental division (cf. Exner et al., 2002; Exner, 2007).

For the territory of Slovakia, two syntaxa checklists of the class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 were published up to the present: (1) Šomšák's list of syntaxa (in Mucina et al., 1985) based mostly on studies of Hadač et al (1969), Šoltés (1976) and Fajmonová (1978), and (2) recent derived checklist of Jarolímek et al. (2008a). Altogether five associations of natural calcicolous Norway spruce communities were traditionally differentiated: *Seslerio-Piceetum*, *Cortuso-Piceetum*, *Adenostylo-Piceetum* within the alliance *Chrysanthemo-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962 as well as *Mnio spinosi-Piceetum*, *Oxalido-Piceetum* classified within *Oxalido-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962 (cf. Kučera, 2012a; Kučera, in red.).

Kučera (2012a) published the first comprehensive syntaxonomical revision of the natural mountain Norway spruce syntaxa within Slovakia. An important part was a commented overview of distribution of the Norway spruce woodlands in the territory of the Western Carpathians, associated with a revision of traditional views on their natural distribution.

Aim of this paper is present an updated syntaxonomical classification of natural calcareous Norway spruce communities found in the territory of the Western Carpathians in Slovakia. The preceding syntaxonomical revisions were dedicated to syntaxonomy of Arolla pine communities (Kučera, 2017; Kučera, 2019b) and coniferous wet woodland communities (Kučera, 2019a, with exception of bog woodland communities).

# Methods

This contribution presents partial results of the syntaxonomical revision of the communities of the class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 present in Slovakia, originally intended to be part of the specialized volume of the *Rastlinné spoločenstvá Slovenska* (1995–) on the forest and scrub vegetation (Valachovič et al., msc.). Therefore the presented relevé dataset selection follows the methodical directions established for that monograph:

(1) The dataset for Slovak forest and scrub phytocoenoses was officially closed to the date 27. 5. 2016 and no newly published relevés were accepted. This regulation was here followed therefore this is the reason why for example numerous relevé data of Arolla pine woodlands published by Zięba et al. (2018) were not included in the statistical comparisons of the *Vaccinio-Piceetea* alliances. The final dataset was exported from Slovak vegetation database (CDF) (see Šibík, 2012; https://www.givd.info/ID/EU-SK-001) by J. Šibík (Institute of Botany SAS, Bratislava) and made available to the respective authors of chapters on Slovakian forest and scrub vegetation.

(2) For forest communities only relevés with plot sizes 200–650 m$^2$ were accepted. This regulation was also strictly followed even if that meant loss of some typical relevés with sizes between 100–200 m$^2$ (for example Hadač et al., 1969, p. 272 etc.[1]).

(3) Selected taxa were merged to species aggregates such as *Dryopteris carthusiana* agg., *Senecio nemorensis* agg. (cf. Valachovič et al., msc.) or to the nearest mutual taxonomical rank (e.g. *Solidago virgaurea* ssp. *minuta* + *Solidago virgaurea*).

The resulting dataset was stored in Turboveg for Windows database software (Hennekens c1998–2020) (cf. Hennekens & Schaminée, 2001) and selection of *Vaccinio-Piceetea* phytocoenoses with respect of above-mentioned limitations was performed by the author. Some of the relevés were revised according to originally published data.

In respect of the thorough revision of literature sources, records of explicit successional stages (e.g. some relevés of Krajina (1933)) as well as relevés with missing ground layer species were excluded. Relevés of phytocoenoses with natural occurrence of *Pinus cembra* were also excluded because they are classified within the alliances *Calamagrostio*

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[1] However, the excluded relevés were considered within the proposal of syntaxonomical classification within the respective associations.

*variae-Pinion cembrae* and *Homogyno alpinae-Pinion cembrae* (cf. Kučera, 2017). With regard to different floristical patterns of calcareous and acid Norway spruce woodlands (cf. Kučera, 2012a), the set of calcicolous phytocoenoses was separated.

In attempt to maximize quality of data selected for statistical classification of Slovak *Picea abies* phytocoenoses of the Western Carpathians, the available relevé data were thoroughly re-analysed with regard to revisions of the natural distribution of *Picea abies* communities in Slovakia (see below). The most important part is to eliminate potential data contamination with floristical and ecological influence of anthropogenically degraded forest communities, especially exclusion of data recorded in unequivocally identified substitutionary Norway spruce stands (see below in the Results, for the detailed explanation see Kučera (2012a)).

As result, a strict restriction of altitudinal limit was adopted: relevé data from localities below the elevation 1400 m a.s.l. were excluded. This subjective decision is based on the field observations of *Fagus* and mixed *Fagus* woodland stands found above 1300 m a.s.l. on expositions of all four cardinal directions, with emphasis on the preserved *Fagus* stands reaching with their artificially lowered upper forest line (!) above 1340–1350 m a.s.l. on non-carbonate bedrock. In the carbonate regions, such artificial upper forest line of mixed *Fagus* woodlands of the class *Carpino-Fagetea* was confirmed in the field above 1360–1390 m a.s.l.

Below the chosen altitudinal limit (1400 m a.s.l.) only carefully selected relevés of *Picea abies* phytocoenoses were accepted into the dataset. They represent plant communities mostly found on ecologically more extreme habitats which hinder development of the *Carpino-Fagetea* communities, within the Western Carpathians for example on considerably steep and rocky habitats with shallow soils which support an extragradal occurrences of natural calcareous Norway spruce phytocoenoses (cf. Fajmonová, 1978).

No other phytocoenological relevés were eliminated, even if they represented untypical of problematically identifiable phytocoenoses. The complete list of the used relevés is summarily presented by Kučera (in prep.), see also below the particular associations.[2]

The final dataset with 80 relevés was exported to the software package JUICE (Tichý c1998–2020) (cf. Tichý, 2002) for further modifications (see above) and, subsequently, exported for statistical analysis performed by the software package SYN-TAX 2000 (Podani, 2001a). The ordinal hierarchical clustering was executed to evaluate also quantitative information provided by ordinal Braun-Blanquet's scale (cf. Kučera, 2011a) and the Podani's discordance coefficient was used as it takes into account also presence vs. absence relation (Podani, 2001b). For confrontation also the ordinal nonhierarchical clusterings were performed using the Podani's discordance coefficient. Further classification comparisons and verifications included variants of the ordinal hierarchical/nonhierarchical clustering without the most species-rich communities ([1] *Seslerio-Piceetum* or [2] *Seslerio-Piceetum* and *Cirsio-Piceetum*).

The final relevé classification is based on classification of data on the field layer ($E_1$) and the ground layer ($E_0$) only, because tree species data deformed the statistical results and for example *Sorbus aucuparia*-pseudocommunities were created without having other sufficient diagnostic floristical attributes. The resulting dendrogram is presented in the Figure 1.

The differential attributes of the respective syntaxa (fidelity and frequency values) and resulting tables were elaborated within JUICE; the concept of fidelity was used (Chytrý et al., 2002a). Fidelity calculations (φ-values) are based on the presence/absence data with a standardization of relevé groups to an equal size. Performing the Fisher's exact test, zero fidelity was given to species with significance $P > 0.05$ in a particular cluster (Tichý & Chytrý, 2006).

The formal sequence of species groups in the Table 2 is adjusted according to the template of differential tables of the Vegetation of the Czech Republic, Vol. 4 (Chytrý et al., 2013a), i.e. trees, shrubs, differential and other species of the field and ground layer separately; constancy and fidelity values equal and higher than "50" are highlighted in boldface type. Statistically determined diagnostic species are ranked according to fidelity values. The conventional levels of statistical significance (0.05, 0.01 and 0.001, Fisher's exact test) for the particular species are indicated with asterisks (*, **, ***). Due to rather low total number of available natural Norway spruce relevés, species with the lowest diagnostic value (Fisher's exact test 0.05-limit) were also retained as "diagnostic species" for individual syntaxa, bearing in mind their availability for future comparisons and potential use during field research.

However, in the text are given in number reduced groups of the recommended diagnostic species (highlighted in grey in the Table 2) to limit the respective species lists, recruited from species which (1) usually have φ-value ≥ 0.50 or (2) are concentrated in the respective community. Non-highlighted statistically defined diagnostic species could also be used for delimitation of the respective

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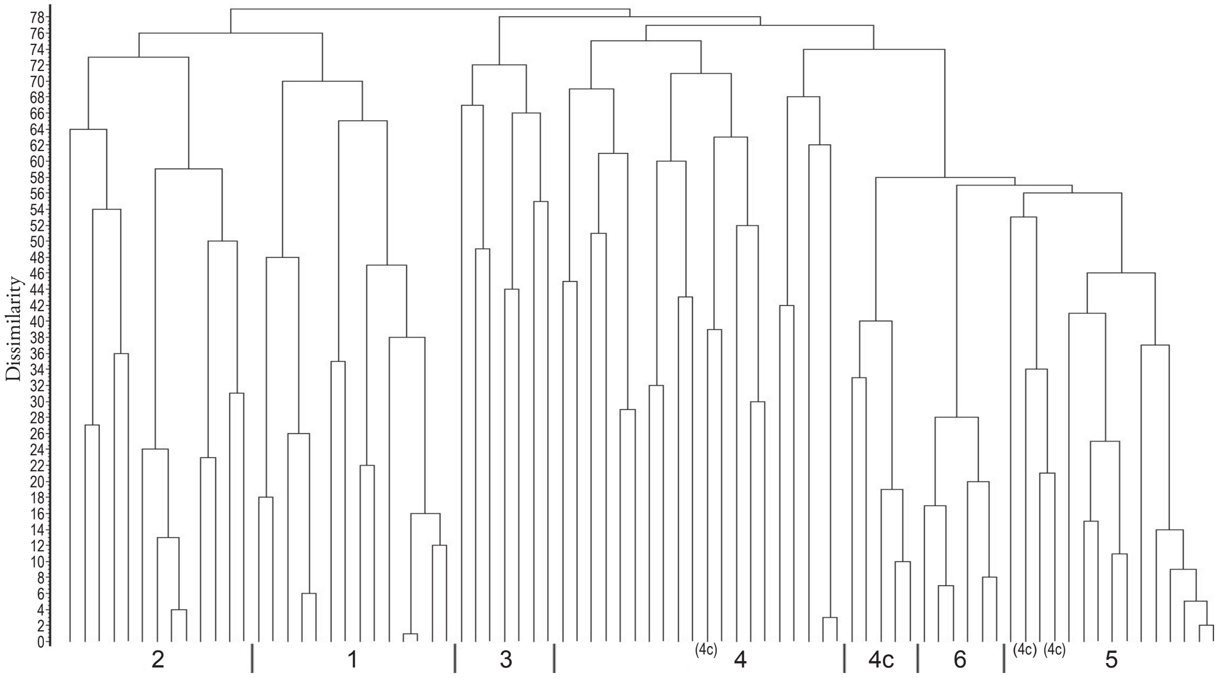
[2] In comparison to the dataset used for calcicolous Norway spruce communities by Kučera (2019a), tab. 1: "76 relevés"), four relevés were added: Kobzáková (1987), tab. 8, rel. 7; Miadok (1995), p. 60, rel. 2; Kučera (2012a), p. 289, rels. 9–10.



1 – *Seslerio caerulae-Piceetum*; 2 – *Cirsio erisithalis-Piceetum,* 3 – *Fragario vescae-Piceetum* ass. prov., 4 – *Adenostylo alliariae-Piceetum,* 4c – *Adenostylo-Piceetum stellarietosum nemorum,* 5 – *Mnio spinosi-Piceetum,* 6 – *Hieracio murorum-Piceetum*

**Figure 1:** Dendrogram of the ordinal hierarchical clustering of the relevés of natural calcareous *Picea abies* communities from Slovakia.
**Slika 1:** Dendrogram ordinalne hierarhične klasifikacije popisov naravnih združb z vrsto *Picea abies* na karbonatu s Slovaške.

community, but only with careful consideration of their association with other species in other communities and also with consideration of their cover-abundance values in the evaluated and other communities: e.g. *Adenostyles alliariae* is frequent species in the whole group of natural calcicolous *Picea abies* woodlands, however, in the association *Adenostylo alliariae-Piceetum* it is (co-)dominant species with very high frequency.

Division of the diagnostic species into differential and Braun-Blanquetian character species is not applied, because (1) this statistical evaluation is based only on limited dataset, (2) character species (for example for Slovak vegetation) are frequently traditionally subjectively assigned to a preselected syntaxa, even in the national monographs, and thus do not rely on statistical determination (for example *Adenostyles alliariae*).

Species taxa names from the Western Carpathian relevés follow checklists of Marhold et al. (1998), Kubinská & Janovicová (1998) and Pišút et al. (1998), exceptions are for example the names of *Sesleria caerulea* (L.) Ard. (cf. Foggi et al., 2001) and *Soldanella marmarossiensis* agg. (*S. hungarica* auct. slov., cf. Valachovič et al., 2019), or other species adapted from the particularly cited studies. Nomenclatural evaluation of the discussed syntaxa names is regulated according to the 4th edition of the Code (Theurillat et al., 2021), highlighted are the cited Code Articles ("Art.") and Recommendations ("Rec."). The names of the classes *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 and *Carpino-Fagetea* Jakucs ex Passarge 1968 are hereafter given without author citations. Common soil names (within the associations'descriptions) are supplemented with the 2006 edition of the World Reference Base for Soil Resources names given according to the reference table in the Societas pedologica Slovaca (2014).

The sites of the analysed relevés within the individual associations in Slovakia are given in the Figures 2 and 3. The coordinates of the dataset relevés taken from the CDF were partially revised, especially those created for older surveys without pre-existing coordinate data. The maps were created using the Free and Open Source QGIS (QGIS.org, 2021), the base layer (terrain) is provided by Geodesy, Cartography and Cadastre Authority of the Slovak Republic (see https://zbgis.skgeodesy.sk).

Extended characterization of the discussed associations – their distribution within the Western Carpathians, ecology, dynamics of the stand, notes to nature conservation – is summarized by Kučera (in prep.), in this paper are mainly discussed: floristical differentiation, syntaxonomical variability as well as important nomenclatural and syntaxonomical problems.

# Results and discussion

## General delimitation of the considered plant communities

Regionally developed intrazonal coniferous orobiomes (i.e. within the nemoral zone) of the main Central European mountain ranges are analogous counterparts of the taiga (zono)biom of the northern Eurasian latitudes. The most frequent and usually the exclusive component of these orobiomes is a *Picea abies* mountain woodland, only the most highest mountain ranges (Alps, Tatra Mountains etc.) possess (mixed) Arolla pine woodlands.

Numerous *Picea abies* plant communities were historically syntaxonomically included into the class *Vaccinio-Piceetea*. Due to the impacts of pre-/historical land management, general patterns of the distribution of Norway spruce stands in the Western Carpathians have considerably changed. Fully in agreement with Zlatník (1959, p. 20) I am of the opinion that the key to understand the original [primary] overall composition of forests in Slovakia is a reconstruction of the natural distribution of *Fagus sylvatica* and its proportional participation on composition of these forests.

This approach requires determination of potential natural distribution of *Fagus sylvatica* or, more precisely, determination of horizontal and vertical potential natural distribution of woodlands (co-)dominated by *F. sylvatica* as well as mixed deciduous-coniferous woodlands of higher montane altitudes with still considerable ecological influence of *F. sylvatica* on the plant species composition of the field layer. The Zlatník's concept of forest vegetation reconstruction (Zlatník, 1957; Zlatník, 1959; Zlatník, 1975; Zlatník, 1976; Zlatník, 1978) is similar to geobotanical reconstruction approaches (cf. Tüxen (1956) and later updates and variations, cf. Neuhäusl (1994)). Moreover in regard to the recent climate change, specialized attention should be paid to the period up to 1950–1980, i.e. before the notable recent anthropogenic impact on climate variables important for the development of woodland orobiomes.

In the territory of the Western Carpathians within Slovakia, planted Norway spruce stands are frequently easily recognizable because they abruptly border to (semi-)natural and more resilient beech or beech-silver fir stands of the class *Carpino-Fagetea* even within the same slope of a valley, i.e. at the originally same habitat. Such plantations have usually limited duration, however, existence of several generations of uninterrupted Norway spruce monocultures is known in some regions (Šimurdová, 2001) or Norway spruce monocultures could have replaced already historically changed forest vegetation (see Nižnanská, 1983). In such cases, centuries long cultivation of Norway spruce stands gradually effects regional species composition and also habitat conditions.

All such plantations represent less or more anthropogenically influenced stages of original plant communities of the class *Carpino-Fagetea* and they should be classified within that class (cf. Hadač & Sofron (1980) and corrections by Kučera (2012a, chap. 5.27); see also Zlatník (1975, p. 83–84, 86).

The higher up into the mountains, the harder becomes the differentiation between the native and anthropogenic Norway spruce stands replacing the original mixed European beech woodland. However, in the Slovakian Western Carpathians the beech-fir woodlands are sufficiently represented even in the altitudes 1000–1200 m a.s.l. therefore the Norway spruce cultures as temporary coniferous stages of *Carpino-Fagetea* communities are mostly reliably identifiable.

### *General lower line of Norway spruce altitudinal vegetation zone in the Western Carpathians*

Throughout the previous decades several variants of the elevational span of the Norway spruce altitudinal vegetation zone were published for the Western Carpathians (see Kučera 2012a, chap. 3): according to various authors, altitudes of the general lower limit of this zone were estimated to different values within the range from (1000) 1100 up to 1250 (1300) m a.s.l., the natural general (i.e. climatic) upper limit was assumed to be situated also at different values ranging from 1300 to 1550 (1600) m a.s.l.

Inconsistency of the referred assessments is evident. Evaluations of the assumed natural altitudinal distribution of Norway spruce woodland within the majority of previous vegetational outlines published for the territory of Slovakia, either from the view of botany (Holub & Jirásek, 1967; Futák, 1972; Michalko & Berta, 1972; Michalko et al., 1980; Michalko et al., 1986; Šomšák, 1998; cf. also Medwecka-Kornaś, 1972) or forest typology (Hančinský, 1972; Hančinský, 1977; Randuška, 1986; Fleischer & Chmiel, 2010; cf. also Minďáš, 1999) and geography (Plesník, 1961; Plesník, 1995; Plesník, 2004) are at least partly unsatisfying (for details see Kučera (2012a)). Debatable geobotanical conclusions of the cited studies and other works were also reflected in specialized manuals for nature conservation (Stanová et al., 2002; Viceníková et al., 2003; and previous versions).

The most probable explanation of inconsistencies between the previously published results and the recently revised field situation is that insufficient attention was paid to identification of anthropogenic, secondary Norway spruce stands in the field, especially within the highest part of the montane altitudinal zone, and to their differentiation from natural Norway spruce woodlands. Formation of the former group is frequently connected with the long-term spontaneous succession of *Picea abies* on formerly deforested areas once used for high mountain grazing or even mowing in some localities (subanthropogenic origin of *Picea* stands; Kučera, 2012a).

In the various Western Carpathian mountain ranges, occurrences of (mixed) upper montane *Fagus* woodlands over the traditionally most accepted general altitudinal limit 1250 m a.s.l. for existence of European beech woodland were confirmed along with a widespread gradual recovery of such forests by the processes of secondary succession of *F. sylvatica* within anthropogenic *P. abies* stands (Kučera, 2011b; Kučera, 2012a; Kučera, 2013a; Kučera, 2014a; Kučera, 2015a; and other until now unpublished sequels in this topic).

Therefore the current general delimitation of the natural distribution of communities of the class *Vaccinio-Piceetea* is based on detailed revision of the occurrences of more or less natural (mixed) *Fagus* woodlands in the field, especially those which existed before 1950s. As such they were recorded in the historical orthophoto map of Slovakia with the oldest aerial photos dated to the year 1949 (Historická ortofotomapa Slovenska s. d.).

Considerably revised was also distribution of so-called *Fagus*-free coniferous woodlands in the middle and lower montane altitudes of Slovak basins and mountain ranges which were also traditionally classified as plant communities of the class *Vaccinio-Piceetea* (e.g. Kučera, 2012b; Kučera, 2012c; Kučera, 2014b; Kučera, 2015b; Kučera et al., 2009).

The above-cited results of the field revision of naturalness of Norway spruce woodland communities in the Western Carpathians signify that the general lower limit of Norway spruce altitudinal vegetation zone (in Latin “gradus” as an altitudinal counterpart to a latitudinal vegetation zone [Latin “zona”], cf. Holub & Jirásek (1967, p. 79–8) and Krippel (1986, p. 260)) should be placed to considerably higher altitudes than traditionally accepted. In Slovakia, this altitudinal limit most probably has not naturally descended below 1350 m a.s.l. at all. In respect to various expositions and mountain ranges, the estimated range is probably within the interval between ca. (1370) 1380–1430 (1450) m a.s.l. It should be emphasized that the respective estimation is projected for 20th century before the era of gradually more visible impacts of the anthropogenic climate change (i.e. before ca. 1990, cf. Lapin et al., 2005; Faško et al., 2008). In addition, important though insufficiently known is the original natural elevational span of the transitional belt between unequivocally classifiable *Carpino-Fagetea* and *Vaccinio--Piceetea* communities.

The extragradal natural occurrences of Norway spruce communities in lower altitudes are, obviously, not counted to that range because the respective communities originated in terrain-induced ecologically extreme habitats inhibiting the development of so-called climax woodlands forming the predominating woodland vegetation (cf. also Zlatník, 1975, p. 103–104; Zlatník, 1978, p. 327–328). Such ecologically peculiar Norway spruce communities are altitudinally lying in the uppermost part of the montane belt occupied by communities of the class *Carpino-Fagetea*. Considering the natural calcareous Norway spruce woodland types, the most frequent examples of such extragradal communities are phytocoenoses of the association *Seslerio-Piceetum* Fajmonová 1978 developed at altitudes below ca. 1370–1400 m a.s.l.

A detailed review of Norway spruce woodlands documented in the individual mountain ranges of the Western Carpathians as well as comments to communities incorrectly classified within the class *Vaccinio-Piceetea* was already published (see Kučera, 2012a). A shortened catalogue of records of the plant communities which should not be considered as natural calcicolous Norway spruce communities is given in the Table 1. As such they should be classified as anthropogenic degraded variants of plant communities of the class *Carpino-Fagetea*, mostly within the order *Cephalanthero damasonii-Fagetalia sylvaticae* Boeuf et Royer in Boeuf et al. 2014,[3] uniting the European calcareous *Fagus* and *Fagus-Abies* woodlands, i.e. communities with ecological conditions and species composition determined by special ecological regime provided by mutual effect of base-rich soils (mostly various calcareous soils: rendzic leptosols, rendzinas, pararendzinas) and distinctive landscape relief usually developed in mountain regions, formed by various sedimentary calcareous rocks (limestones, dolomites etc.). Some of the considered secondary Norway spruce communities also might belong to the group of mesotrophic (silicicolous to semicalcicolous) woodlands united into the order *Fagetalia sylvaticae* Tüxen 1931[4,5] (cf. Boeuf et al., 2014).

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[3] Cf. the proposal of classification of (mixed) *Fagus* woodlands within the class *Carpino-Fagetea* into three cardinal units by Boeuf et al. (2014).

[4] Willner (in Willner et al., 2015) argued for validity of the order name *Fagetalia sylvaticae* Pawłowski 1928. Despite the all argumentation, Pawłowski (1928, p. 15) did not provide a real unambiguous direct or indirect reference to an earlier effectively published sufficient diagnosis (cf. Theurillat et al., 2021: Art. 2b). Scientific nomenclatural evaluations and decisions should be based on clearly stated information or data presented in the considered source; on the contrary, obscure guessing and wishing of a “proper reference” do not count among convenient scientific approaches. Therefore I identify with

The catalogue given in the Table 1 demonstrate that anthropogenic calcicolous Norway spruce phytocoenoses were recorded in rather large number within the Western Carpathians. Probably most of them were used in the specialized statistical surveys on either diagnostic and other significant species (cf. Chytrý et al., 2002b; Jarolímek et al., 2008b; cf. also Jahn, 1985; Exner et al., 2002) or phytocoenological affinity of a chosen taxon (cf. Valachovič et al., 2019) – see the very high total number of relevés used in that studies in comparison to the here presented syntaxonomical revision. Therefore the respective results of those studies are misleading or incorrect when considering the class *Vaccinio-Piceetea* because they factually represent a mixture of relevé data of two classes: *Carpino-Fagetea* and *Vaccinio-Piceetea*. In contrast to the statement of Chytrý et al. (2002b, p. 406) I am of the opinion that the number of secondary Norway spruce relevés (belonging to the class *Carpino-Fagetea*) used in that study (and similar other studies) represented a considerable part of evaluated relevé data.

**Table 1:** Catalogue of records of the anthropogenic calcicolous (mixed) Norway spruce phytocoenoses incorrectly classified within the class *Vaccinio-Piceetea.*

**Tabela 1:** Seznam literaturnih virov z antropogenimi smrekovimi združbami na karbonatnih (mešanih) substratih, nepravilno uvrščenih v razred *Vaccinio-Piceetea.*

"Only published studies are listed, for details on manuscripts' details see Kučera (2007, 2012a). Geomorphological units are given according to Kočický & Ivanič (2011)."

**Part 1.** Slovakia

| Authors | Geomorphological unit | Original name of unit | Proportion of *Carpino-Fagetea* relevés | Remarks |
|---|---|---|---|---|
| Klika (1926) | Veľká Fatra | Piceetum excelsae | All relevés | |
| Klika (1929) | Veľká Fatra, Krivánska Fatra | Typ borůvkový, *Vaccinium myrtillus-Calamagrostis varia* | All relevés | |
| Sillinger (1933) | Ďumbierske Tatry, Kráľovohoľské Tatry | Piceetum excelsae normale calcicolum | All relevés | Only synoptic table. Author's original alternative name: *Piceeto-Abietetum normale calcicolum* Sillinger 1933. |
| Sillinger (1933) | Ďumbierske Tatry, Kráľovohoľské Tatry, Slovenský raj | Piceetum excelsae altherbosum calcicolum | Pro parte maj. | Only synoptic table. |
| Sillinger (1933) | Ďumbierske Tatry, Kráľovohoľské Tatry, Slovenský raj | Piceetum excelsae myrtilletosum calcicolum | Almost all relevés | Only synoptic table. |
| Svoboda (1939) | Západné Tatry | Piceetum altherbosum | Pro parte | Only synoptic table. |
| Grebenščikov et al. (1956) | Veľká Fatra | *Piceetum excelsae myrtilletosum* Klika | Page 117–118 | |
| Grebenščikov et al. (1956) | Veľká Fatra | fragments of Norway spruce woodland with *Cortusa matthioli* and *Luzula sylvatica* | Page 119 | |
| Samek et al. (1957) | Vysoké Tatry, Belianske Tatry | *Piceetum excelsae altherbosum/ Adenostyleto-Piceetum* | Pro parte | |
| Samek et al. (1957) | Vysoké Tatry | Piceetum normale silicicolum | All relevés | Phytocoenoses in fact considerably influenced by carbonate rocks. |
| Samek et al. (1957) | Vysoké Tatry (? Belianske Tatry) | Piceetum normale calcicolum | ? Pro parte | |

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Theurilat's conclusion (in Willner et al., 2015, p. 177) that the name *Fagetalia sylvaticae* Pawłowski 1928 is the invalidly published name. The derived later name *Fagetalia sylvaticae* Pawłowski ex Pawłowski et al. 1928 is invalidly published as well (cf. Kučera, 2013b); the oldest validly published *Fagetalia*-name is *Fagetalia sylvaticae* Tüxen 1931 and it has already been recognized by Boeuf et al. (2014), see also Renaux et al. (2019).

[5] This order name is based on the alliance *Fagion septentrionale* Tüxen 1931 nom. illeg. (Art. 34a) described for calcicolous *Fagus sylvatica* phytocoenoses of the Hildesheimer Wald–Ith region in northern Germany. Following the original diagnosis, the order is not characterized by distinctive calciphytes, however, the phytocoenotic composition of the respective association *Fagetum subhercynicum* Tüxen 1931 (Tüxen, 1931, p. 104 and the attached table) is clearly influenced by the calcareous geological substrate.

| Authors | Geomorphological unit | Original name of unit | Proportion of *Carpino-Fagetea* relevés | Remarks |
|---|---|---|---|---|
| Samek et al. (1957) | Vysoké Tatry (? Belianske Tatry) | Abieto-Picetum | All relevés | |
| Zahradníková-Rošetzká (1957) | Ďumbierske Tatry | *Piceetum excelsae normale calcicolum* Sillinger 1933 | – | (Without relevés.) |
| Zahradníková-Rošetzká (1957) | Ďumbierske Tatry | *Piceetum excelsae altherbosum calcicolum* Sillinger 1933 | Pro parte min. | (Without relevés.) |
| Hadač et al. (1969) | Belianske Tatry | *Dryoptero-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969 | All relevés | The original relevés represent two different communities (calcicolous: 119, 185, 254 vs. silicicolous: 225, 253). |
| Hadač et al. (1969) | Belianske Tatry | *Chrysanthemo-Piceetum* Krajina 1933 | Pro parte | The association name was used as a pseudonym: *Chrysanthemo-Piceetum* sensu Hadač et al. 1969 non Krajina 1933 (cf. Kučera in red.). |
| Hadač et al. (1969) | Belianske Tatry | *Adenostylo-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969 | Pro parte min. | |
| Zlatník (1970) | Vysoké Tatry | groups of forest types: Aceri-Abieteta piceae, Abieti-piceeta | All relevés | |
| Šmarda et al. (1971) | Belianske Tatry | *Sorbeto-Piceetum calcicolum* Pawłowski 1956 | Pro parte | Nomen fictum, thus the adequate form is *Sorbo-Piceetum calcicolum* Šmarda et al. 1971. |
| Šmarda et al. (1971) | Belianske Tatry | *Abieto-Piceetum* Szafer et Sokołowski 1927 | All relevés | Originally as a facies, therefore the association should be cited as “*Abieto-Piceetum* Šmarda et al. 1971”. |
| Šmarda et al. (1971) | Belianske Tatry | *Acereto-Piceetum* Šmarda 1958 | All relevés | I.e. *Acero pseudoplatani-Piceetum* Šmarda ex Šmarda et al. 1971 |
| Kubíček & Jurko (1975) | Západné Tatry | *Adenostylo-Piceetum typicum* Šoltés 1971 [originally nom. ined.] | Pro parte | |
| Šoltés (1976) | (higher number of units) | Adenostylo-Piceetum cortusietosum | Pro parte maj. | Only newly published relevés are considered (Šoltés 1976, tab. 3). |
| Šoltés (1976) | Belianske Tatry | Vaccinio myrtilli-Piceetum calamagrostietosum variae | Pro parte | Only newly published relevés are considered (Šoltés 1976, tab. 4). |
| Fajmonová (1978) | (not specified) | *Oxalido-Piceetum* (Krajina 1933) Březina et Hadač in Hadač et al. 1969 | Pro parte | Correct name: *Oxalido-Piceetum* Březina et Hadač in Hadač et al. 1969 (cf. Kučera in red.). |
| Fajmonová (1978) | (not specified) | *Cortuso-Piceetum* (Sillinger 1933) Šoltés 1976 | Pro parte | Nomen fictum, the most probable correct form is “*Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978”, see explanation in the text. |
| Fajmonová (1983) | (higher number of units) | *Cortuso-Piceetum* (Sillinger 1933) Šoltés 1976 | Pro parte maj. | |
| Unar et al. (1984) | Západné Tatry | *Adenostylo-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969 | All relevés | |
| Fajmonová (1986) | (higher number of units) | *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978 | Pro parte | |

| Authors | Geomorphological unit | Original name of unit | Proportion of *Carpino-Fagetea* relevés | Remarks |
|---|---|---|---|---|
| Uhlířová & Bernátová (1986) | Veľká Fatra | Phytocoenosis with *Listera cordata*, rel. 1. | – | Probably more suitable to classify as a marginal community of the class *Erico-Pinetea* Horvat 1959. |
| Voško et al. (1990) | ? Belianske Tatry | Group of forest types Sorbi ariae-Piceeta | All relevés | |
| Kubíček et al. (1992) | Belianske Tatry | *Adenostylo-Piceetum* (Sillinger 1933) Šoltés 1976 | Rel. 5. | |
| Kubíček et al. (1992) | Belianske Tatry | *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978 | Rel. 7. | |
| Černušáková (1994) | Západné Tatry | *Calamagrostio villosae-Piceetum* (Tx. 1937) Hartmann 1953 | Pro parte | |
| Černušáková (1994) | Západné Tatry | *Athyrio alpestre-Piceetum* (Hartmann 1953) Hartmann et Jahn 1967) | Pro parte | |
| Školek (1995a) | Ďumbierske Tatry | Higher number of units | ? All relevés | Only synoptic table. |
| Školek (1995b) | Ďumbierske Tatry | *Carici albae-Piceetum* Školek 1995 | All relevés | |
| Školek (2003) | Ďumbierske Tatry | Higher number of units | Pro parte | (Without published relevés.) |
| Kanka (2008) | Belianske Tatry | Higher number of units | Pro parte | Including *Athyrio alpestris--Piceetum* (rels. 3, 4) and *Dryopterido-Piceetum* (rels. 1–4, 6) |
| Krajčí (2008) | Kráľovohoľské Tatry | *Cortuso-Piceetum* (Soltés 1976) Fajmonová 1978 | All relevés | Cf. also Krajčí & Barančok (2009). |
| Valachovič et al. (2019) | | Piceion excelsae | Pro parte | Authors evaluated only relevés with presence of genus *Soldanella*. |

**Part 2.** Selected examples from the mountain ranges of the Western Carpathians in Poland. The respective habitats do not occurr in Moravia and Silesia.

| Authors | Geomorphological unit | Original name of unit | Proportion of *Carpino-Fagetea* relevés | Remarks |
|---|---|---|---|---|
| Szafer et al. (1923) | Západné Tatry | *Piceetum normale* Beger 1922 | Pro parte maj. | |
| Szafer et al. (1923) | Západné Tatry | Piceo-Abietetum albae | All relevés | |
| Szafer et al. (1927) | Západné Tatry | *Piceetum excelsae normale*, typical facies | Pro parte maj. | |
| Szafer et al. (1927) | Západné Tatry | *Piceetum excelsae normale*, *Polytrichum* facies | Pro parte maj. | |
| Szafer et al. (1927) | Západné Tatry | Abieteto-Piceetum | All relevés | |
| Kulczyński (1928) | Pieniny | Piceetum excelsae | A species list | Cf. Kučera (2015b) |
| Adamczyk (1962) | Západné Tatry | Piceetum excelsae tatricum | Pro parte maj. | |
| J. Matuszkiewicz (1977) | – | *Galio rotundifolii-Piceetum carpaticum* J. Matuszkiewicz 1977 | All relevés | |
| J. Matuszkiewicz (1977) | (Západné Tatry) | *Polysticho-Piceetum* W. Matuszkiewicz ex J. Matuszkiewicz 1977 | Pro parte | |

## General upper line of Norway spruce altitudinal vegetation zone in the Western Carpathians

As written above, the general upper limit of the Norway spruce altitudinal vegetation zone for the Western Carpathians was estimated in various altitudes from the elevational range 1300 to 1550 m a.s.l. As the uppermost yet anthropogenically lowered upper limits of mixed montane *Fagus* woodlands was recorded above 1360–1390 m a.s.l. (Kučera, 2012a) and natural Norway spruce zone is developed in every individual mountain range with sufficient altitudinal elevations, these traditionally accepted estimates should be reassessed as well.

According to the total altitudinal height of a particular mountain range, three categories could be differentiated when considering the Norway spruce altitudinal vegetation zone of the Western Carpathians in Slovakia:

(1) mountain ranges which do not exceed the alpine forest line (see the notes below), for example the Veporské vrchy Mts (Fabova hoľa-group), the Stolické vrchy Mts (Stolica–Kohút group);

(2) mountain ranges with the most highest isolated summits or more continuous areas exceeding this line, for example the Oravské Beskydy Mts or the Low Tatras (Nízke Tatry Mts);

(3) high mountain ranges which provided a postglacial (especially post-Boreal and post-Atlantic) refugium (cf. Krippel, 1986) for survival of *Pinus cembra* populations and therefore the alpine forest line (and consequently the alpine treeline) is determined by *Pinus cembra* (together with *Larix decidua* and partially *Picea abies*), i.e. the Tatra Mountains (equivalently to the Alps), whereby this species change has also considerable effect on the altitudinal rise of the upper forest line in comparison to the other Western Carpathian mountain ranges (Plesník, 1971); however, historical deforestation considerably reduced or destroyed native mixed Arolla pine forests, especially in their western (Západné Tatry Mts) or eastern part (Belianske Tatry Mts) (cf. Kučera (2019b, chapter 3.3), and Zięba et al. (2019), detailed distribution map in their el. appendix).[6]

When considering the third category, it should be noted that the natural development of *Picea abies* (or *Picea-Larix*) woodlands was altitudinally considerably narrowed due to competition with mixed Arolla pine woodlands, syntaxonomically classified within either the alliance *Calamagrostio variae-Pinion cembrae* or the alliance *Homogyno alpinae-Pinion cembrae* (see Kučera, 2017). While in the lower altitudes (for example above 1400 m a.s.l.) spontaneously rejuvenated *Pinus cembra* individuals are – in ecologically favourable habitats – overshadowed by much taller *Picea abies* trees and they wither away, the interspecific competition has a different outcome in the higher elevations (for example above ca. 1500–1550 m a.s.l.) where the total height of *Picea abies* trees is lower: Norway spruce woodland is thus replaced with mixed Norway spruce-Arolla pine and subsequently with mixed Arolla pine woodlands. However, historical land management considerably changed the original distribution patterns of the respective woodland communities.

Historical deforestation also played an essential role for the development of the current upper forest line in the Western Carpathian mountain ranges of the second above-differentiated category. By no means could it be identified with the alpine forest line of the potential natural vegetation formed by Norway spruce woodland (cf. Plesník, 1954; Plesník, 1966; Plesník, 1975; Plesník, 1978). According to my current field knowledge, the natural upper Norway spruce forest line was generally developed above 1650 m a.s.l. (for the period up to 1950–1980). Only severe ecological conditions controlling the vegetation development on top regions of some elevated isolated mountains could induce occurrence of lower lying upper forest line: patches of *Picea* krummholz stands or, alternatively, mixed *Pinus mugo* scrub were originally developed before the historical deforestation.

Substantial ecological changes on largely and deeply deforested mountain slopes and ridges (as for example in the southern part of the Veľká Fatra Mts) significantly retard the regeneration, i.e. the reverse spontaneous secondary succession of Norway spruce forests to their former prehistorical habitats; the similar effect have *Pinus mugo* afforestantions in lower altitudes of the former high mountain pastures (cf. example given by Kučera (2019b)).

## A note to terminology of the Picea abies altitudinal vegetation zone

Woodlands of the European *Picea abies* altitudinal vegetation zone are labelled with different adjectives in Central

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[6] As the last glacial mixed *Pinus cembra* woodland was present in the Podtatranská kotlina Basin lying between the Tatra Mountains and the Low Tatras as well as in other rather unexpected regions (Jankovská, 1984; Jankovská, 1991; Jankovská et al., 2002; Jankovská et al., 2018; Pokorný et al., 2015), it may be expected that *Pinus cembra* was a native tree of the lowest parts of Low Tatras' slopes during the more favourable periods of the Würm glaciation and after its ending the species probably survived the Atlantic period – similarly like within the Tatra Mountains – also in the uppermost elevations of the highest parts of the Low Tatras and on other ecologically extreme habitats, as for example rugged rocky terrain of some carbonate summits (Krakova hoľa Mt. etc.). Due to considerably small area they could be easily completely destroyed by later pre-/historical land management (for example the upper parts of the Krakova hoľa Mt. were deforested). Up to the 20th century, segments of the natural alpine forest line did not preserve within the entire region of the Low Tatras.

European literature, which are, likewise, applied in alternative short names of the respective altitudinal zones. The variety of terms was indicated for example by Jahn (1977, p. 478–480), see the following list:

- "high montane" in the sense of German "hochmontan", i.e. lying above the uppermost part of (further divided) montane zone (Hartmann & Jahn, 1967; W. Matuszkiewicz, 1984);
- "upper montane" in the terms of other Polish authors who divide the montane zone to (1) the mostly *Fagus sylvatica*-dominated "regiel dolny" and (2) the *Picea abies*-dominated "regiel górny" (Pawłowski, 1928; Pawłowski, 1956; Medwecka-Kornaś, 1972; W. Matuszkiewicz 1981; W. Matuszkiewicz, 2014; Mirek & Piękoś-Mirkowa, 1992)
- "supramontane" (Domin, 1923;* Holub & Jirásek, 1967; Neuhäuslová-Novotná, 1994; Neuhäuslová et al., 2001; Jirásek, 2002; Chytrý et al., 2013b); *Domin applied the term also for high altitude *Fagus sylvatica* woodlands reaching the upper forest line (cf. also Klika, 1936), however, in the Western Carpathians such upper forest line woodlands are the result of past deep deforestation of slopes (see above);
- "oreal" (Rothmaler 1950, ca. also Haeupler, 1970; cf. Holub & Jirásek, 1967);
- "subalpine" for the highest Norway spruce zone in old Czechoslovak botanical literature: Sillinger (1933); Klika (1936); Svoboda (1939);
- ocassionally also "altomontane" – as a replacement for German "hochmontan" (Meusel et al., 1965, p. 21).

Special case is the simultaneous application of two terms for natural Norway spruce woodlands:

- "montane" and "supramontane" (Neuhäuslová et al., 2001), "supramontane" to "subalpine" (Jirásek, 2002, p. 78);
- "high montane" of so-called mittelgebirge mountain ranges and "subalpine" for the hochgebirge mountain ranges, e.g. the Alps (Oberdorfer, 1957; Hartmann & Jahn, 1967; Jahn, 1977; Pott, 1992; Seibert, 1992; cf. Kuoch, 1954; Exner, 2007);
- "montane" and "subalpine"/"low subalpine" or in German also "tiefsubalpin" to two groups of altitudinally differentiated coniferous, especially Norway spruce communities of the Alps (Ellenberg, 1963 and later editions; Mayer & Hofmann, 1969; Elenberg & Klötzli, 1972; Zukrigl, 1973; Mayer, 1974; Mayer, 1984; Horvat et al., 1974; Pignatti, 1998; cf. Braun-Blanquet et al., 1939; Braun-Blanquet et al., 1954; Kuoch, 1954; Pott, 1992; Exner, 2007; Chifu, 2014; Pignatti & Pignatti, 2014); see also similar approach of Sillinger (1933) and Svoboda (1939) for Tatra Mountains' and Low Tatras' Norway spruce forests;
- "upper montane" and "subalpine" (Coldea, 2015);
- "altimontane" and "subalpine" (Šilc & Čarni, 2012; Juvan et al., 2013);
- "oreal" and "subalpine" (Haeupler, 1970; cf. Jahn, 1977).

Terminological unification seems to be difficult because the particular terms are associated with different traditional use within the individual European regions. Instead of lengthy descriptions and characterizations of individual approaches and subsequent additional reasoning, the following short proposal should be presented in this place.

The term *alpine forest line* (closely connected with the alpine tree line) (see Körner, 2012) should be chosen as the crucial terminological base: the alpine forest line represents one of the several types of general climate-driven forest lines (arctic forest line etc.); other special forest lines – e.g. orographic, edaphic – are natural ecological limits of different kind as they are "disrupting" the general patterns of vegetation development of a particular region/area (cf. Wraber, 1970; Plesník, 1971; Mayer, 1984; Ellenberg, 1996). In contrast to the evaluation of Jeník & Lokvenc (1962), the mechanically changed course of upper forest line (avalanches, snow patches [nivation], debris flows etc.) could not be labelled as part of an "alpine forest line" because the absence of tree stands is there not caused by the alpine climate. Use of the term "artificial alpine forest line" (Jeník & Lokvenc, 1962, p. 24) is controversial as well, especially if the respective anthropogenic modification resulted in decrease of the upper forest line in tens or hundreds of metres (cf. Plesník, 1971; Plesník, 1978; Wraber, 1970).

The alpine climate inhibits formation of woodland communities and only non-forest plant communities are present, with the special case of krummholz belt in lower elevations of the alpine region of some mountain ranges (Domin, 1923; Rothmaler, 1955; Meusel et al., 1965, p. 21; Holub & Jirásek, 1967). A krummholz belt formed by *Pinus mugo* [s. str.] scrub is a distinctive feature of the Carpathian mountain ranges and other European mountain ranges as Sudetes (the Krkonoše Mts.) (Holub & Jirásek, 1967; Medwecka-Kornaś, 1972), Dinarides, Apennines and also of the great part of the Alps (Jalas & Suominen, 1973, map 169; Horvat et al., 1974; Ellenberg, 1996, fig. 226; Pignatti et al., 2017); however, it could be formed by *Picea abies*-krummholz (primarily in the Hrubý Jeseník Mts.) or other (also broadleaf) species in the mountain ranges where *Pinus mugo* (or *Picea abies*) does not naturally forms an altitudinal vegetation zone.

Therefore the adjective term "alpine" (and its derivatives, e.g. subalpine) should be only associated with vegetation types above the alpine forest line (see already Meusel et al., 1965), while the various mountain forest types below this line – and reaching this line – should be labelled with the adjective term “montane” (and its various derivatives) (see Domin, 1923; Holub & Jirásek, 1967; Mirek & Piękoś-Mirkowa, 1992) as indicated in the following scheme:[7]

| nival (sensu lato) | nival<br>subnival | nival sensu stricto |
|---|---|---|
| *climatic perennial snow line* | *climatic perennial snow line* | *climatic perennial snow line* |
| alpine (sensu lato) | alpine (upper, lower)* | alpine sensu stricto |
| | subalpine | |
| *alpine forest line* | *alpine forest line* | *alpine forest line* |
| montane (sensu lato) | supramontane** | |
| | upper montane | montane sensu stricto |
| | lower montane | |
| | submontane | |
| complex of planar and colline zones*** | colline<br>planar | |

* An analogous term “supraalpin” (to supramontane) is applicable for special non-European climate-driven high-altitude regions extensively without continuous snow and simultaneously vegetation cover (for example region of Ojos del Salado in the Andes, Gspurning et al. (2006)). The “vegetation-free” rocky steep slopes/walls of peaks of the High Tatras (or in the montane-alpine elevations the Alps) does not belong here, because they are caused by orographic, not climatic conditions.

** In some European mountain ranges, *Picea abies* does not form an altitudinal zone due to phytochorological or other reasons (the Massif Central, the Vosges, as well as some Southeastern European mountain ranges; Issler, 1942; Horvat et al., 1974; Boeuf et al., 2014), therefore the physiognomically distict (coniferous) uppermost subzone of the montane zone (sensu lato) is not developed. Their uppermost *Fagus sylvatica* horizon corresponds to other beech woodlands of higher montane elevations (e.g. upper montane Western Carpathian mixed *Fagus* woodland above ca. 1250–1300 m a.s.l.) and, consequently, as such it should not be labelled as a supramontane zone. However, physiognomically distinct supramontane zone could be formed by other species when *Picea abies* is naturally absent – see the example of woodlands of *Pinus uncinata* Ramond ex DC s. str. in the Pyrenees (Vigo, 1979).

The Tatra Mountains (and few other European regions, Jalas & Suominen, 1973) with their hochgebirge character are distinct by the native occurrence of *Pinus cembra* preserved in the form of postglacial refugia (Jankovská, 1991). As the presence of this tree species considerably transforms the altitudinal pattern of the alpine forest line in comparison to other (mittelgebirge) mountain ranges with native Norway spruce belt and simultaneously with Arolla pine absence (Plesník, 1971; Kučera, 2012a; Zięba et al., 2019), the respective high mountain mixed *P. cembra* woodlands could be labelled with the adjective “*altimontane*” (= occurring in the very high montane altitudes).[8] In the Pyrenees the similar role is taken by high-altitude *Pinus uncinata* woodland (cf. Rivas-Martínez, 1968).

*** See Haeupler (1970).

According to this proposal, natural *Picea abies* altitudinal vegetation zone (including the mixed *Picea-Larix decidua* communities of some regions) in the mountain ranges of Central Europe (with Alps) to Southeastern Europe (Southern Carpathians) would be labelled as “supramontane zone”, irrespective of the total altitudinal limits reached in the particular region. Only those Alpic Norway spruce forests of the so-called Zentralalpen zone, which altitudinally correspond to the Randalpen upper montane mixed *Fagus* forests, should be labelled as woodlands of the montane zone s. l.; however, their spatial distribution should be revised (see below p. 140).

The term “oreal” (proposed by Rothmaler (1950)) is based on the Greek equivalent to Latin expressions “montana, montanus”; it was also preceded by the older Domin’s term “supramontane” (Domin, 1923) which is therefore here prioritised.

However, the term “oreal” could be advantageously applied for plant species which have their altitudinal centre of distribution in higher montane altitudes as well as in subalpine altitudinal zone, for example *Adenostyles alliariae*, *Athyrium alpestre*, *Calamagrostis villosa*, *Cicerbita alpina*, *Doronicum austriacum*, *Homogyne alpina*, *Gentiana asclepiadea*, *Luzula sylvatica*, (*Streptopus amplexifolius*, *Trientalis europaea*) etc.[9] These are species which grow (for example in the Western Carpathians) mainly in the uppermost horizon of montane mixed *Fagus sylvatica* woodlands, in the supramontane *Picea abies* forests, in the subalpine *Pinus mugo* krummholz, and at the same time in montane to subalpine agradal[10] tall-forb communities

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[7] Position of “sub-zones” are following the classification of Rothmaler (1955) and Löve (1970, section Etymology); however, the label “subalpine zone” is here applied for the krummholz zone only (see above).

[8] Juvan et al. (2013) used the labels “altimontane” and “subalpine” for two groups of coniferous forests which could correspond to the above proposed term “supramontane”. However, the very high frequencies of *Fagus sylvatica* (73% and 58%) indicate the considerable proportion of data recorded in changed secondary forests, thus belonging to the class *Carpino-Fagetea* (see above p. 111–113).

[9] The respective species are incorrectly labelled as “subalpine species” in Slovak forest science handbooks (e.g. Randuška (1986) and later editions) despite the fact that their altitudinal centre of distribution is below the (potential natural) alpine forest line which lies above 1650 m a.s.l., respectively above 1800 a.s.l. for *Pinus cembra* forests of the Tatra Mountains.

[10] See above for the differentiation between Latin “zona” and “gradus”; thus the terms “azonal/extrazonal” and “agradal/extragradal” have separate distinct meanings.

of the classes *Mulgedio-Aconitetea* Hadač et Klika in Klika 1944 and *Betulo carpaticae-Alnetea* Rejmánek ex Boeuf et al. in Boeuf et al. 2014.

## Associations of calcareous Norway spruce woodlands in Slovakia

Six basic natural calcicolous Norway spruce plant communities are differentiated in this syntaxonomical revision. They are here arranged according to ecological gradient provided by carbonate rocks.

Stands of the association *Seslerio caeruleae-Piceetum* are developed on edaphically extreme carbonate habitats with shallow soils. The three subcommunities of the association *Cirsio erisithalis-Piceetum* correspond to the continual improvement of habitat conditions (higher soil depth and humidity). On even deeper soils are developed stands of the association *Fragario vescae-Piceetum* or, alternatively, more widespread tall-forb woodlands of the association *Adenostylo alliariae-Piceetum* which are bound to habitats with favourable water regime. The last two associations represent marginal units of calcicolous natural Norway spruce woodlands because the presence of calciphytes is reduced. The association *Mnio spinosi-Piceetum* is mostly negatively differentiated; however, it is related with phytocoenoses of the previous association. The stands of *Hieracio murorum-Piceetum* are developed over mostly deep soils acidified in their uppermost horizon.

**Table 2.** Statistical comparison of associations of the alliance *Cortuso matthioli-Piceion abietis* P. Kučera 2022 in Slovakia with values of constancy (%) and fidelity (φ (×100) ≥ 25) in the exponent.

**Table 2.** Statistična primerjava asociacij zveze *Cortuso matthioli-Piceion abietis* P. Kučera 2022 na Slovaškem s prikazano stalnostjo (%) in nadpisano navezanostjo (φ (×100) ≥ 25).

Field and ground layer species represented in only one column are omitted.

Group 1 – *Seslerio caeruleae-Piceetum abietis* Fajmonová 1978 nom. corr. et nom. cons. propos.
Group 2 – *Cirsio erisithalis-Piceetum abietis* Fajmonová et P. Kučera in P. Kučera 2022 ass. nov.
Group 3 – *Fragario vescae-Piceetum abietis* P. Kučera ass. nov. prov.
Group 4 – *Adenostylo alliariae-Piceetum abietis* Samek et al. 1957 nom. corr. et nom. cons. propos.
Group 5 – *Mnio spinosi-Piceetum abietis* Hadač et al. 1969 nom. corr.
Group 6 – *Hieracio murorum-Piceetum abietis* P. Kučera 2022 ass. nov.

The quantity of asterisks in the second column express the highest state of conventional levels of the statistical significance (0.05, 0.01 and 0.001, Fisher's exact test) for the particular species. In the case of differential species for multiple units such indication could have alternative states.

| Group No. | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| No. of relevés | | 14 | 13 | 6 | 28 | 13 | 6 |
| Average number of species | | 54 | 53 | 49 | 47 | 23 | 31 |
| **Tree and shrub species** | | | | | | | |
| **Canopy ($E_3$)** | | | | | | | |
| *Picea abies* | | **100**$^{-}$ | **100**$^{-}$ | **100**$^{-}$ | **96**$^{-}$ | **100**$^{-}$ | **100**$^{-}$ |
| *Sorbus aucuparia* | *** | 21$^{-}$ | **85**$^{55.0}$ | 17$^{-}$ | 43$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Acer pseudoplatanus* | * | 7$^{-}$ | 38$^{25.3}$ | **50**$^{39.0}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Larix decidua* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 7$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Sorbus aria* agg. | *** | .$^{-}$ | 31$^{52.0}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Abies alba* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | .$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Fagus sylvatica* | | .$^{-}$ | 8$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Salix silesiaca* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| **Understorey ($E_2$)** | | | | | | | |
| *Sorbus aucuparia* | * | 7$^{-}$ | 38$^{-}$ | 17$^{-}$ | 46$^{26.4}$ | 23$^{-}$ | .$^{-}$ |
| *Picea abies* | | 21$^{-}$ | 23$^{-}$ | 33$^{-}$ | 18$^{-}$ | 23$^{-}$ | .$^{-}$ |
| *Ribes petraeum* | ** | .$^{-}$ | 8$^{-}$ | 17$^{-}$ | 32$^{27.8}$ | 15$^{-}$ | .$^{-}$ |
| *Pinus mugo* | ** | 43$^{40.1}$ | 31$^{-}$ | .$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Salix silesiaca* | * | 7$^{-}$ | 31$^{35.0}$ | .$^{-}$ | 14$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Acer pseudoplatanus* | * | .$^{-}$ | 31$^{27.6}$ | 33$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Fagus sylvatica* | | .$^{-}$ | 15$^{-}$ | .$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |

| Group No. | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| *Sorbus aria* agg. | ** | . – | 23 $^{44.7}$ | . – | . – | . – | . – |
| *Lonicera nigra* | | . – | . – | 17 – | 7 – | . – | . – |
| *Rosa pendulina* | | . – | . – | 17 – | 4 – | . – | . – |
| *Daphne mezereum* | | . – | 8 – | . – | . – | . – | . – |
| *Salix caprea* | | . – | . – | . – | 4 – | . – | . – |
| *Betula carpatica* | | . – | . – | . – | 4 – | . – | . – |
| *Ribes alpinum* | | . – | . – | . – | 4 – | . – | . – |
| *Sambucus racemosa* | | . – | . – | . – | 4 – | . – | . – |
| *Ribes uva-crispa* | | . – | . – | . – | . – | 8 – | . – |
| **$E_1$** | | | | | | | |
| *Sorbus aucuparia* | * | **93** $^{27.5}$ | . – | **67** – | **75** – | **62** – | **83** – |
| *Daphne mezereum* | *** | **93** $^{38.3}$ | **85** $^{30.9}$ | **83** – | 39 – | . – | . – |
| *Lonicera nigra* | ** | **64** $^{33.9}$ | 23 – | 33 – | **57** $^{26.9}$ | . – | . – |
| *Picea abies* | * | . – | 31 – | **50** – | 36 – | 31 – | **83** $^{41.3}$ |
| *Ribes petraeum* | *** | . – | . – | **50** – | **61** $^{41.3}$ | 23 – | . – |
| *Acer pseudoplatanus* | * | 14 – | 23 – | 17 – | 25 – | . – | **67** $^{44.2}$ |
| *Salix silesiaca* | *** | 7 – | 46 $^{46.2}$ | . – | 4 – | . – | 17 – |
| *Rosa pendulina* | | 21 – | 15 – | 17 – | 7 – | . – | . – |
| *Fagus sylvatica* | *** | . – | . – | . – | 4 – | . – | **50** $^{64.4}$ |
| *Ribes uva-crispa* | * | . – | . – | . – | 14 $^{34.9}$ | . – | . – |
| *Ribes alpinum* | * | . – | . – | . – | 11 $^{30.2}$ | . – | . – |
| *Sorbus aria* agg. | * | . – | 15 $^{36.3}$ | . – | . – | . – | . – |
| *Abies alba* | | . – | . – | 17 – | . – | . – | . – |
| *Pinus cembra* | | . – | . – | . – | 4 – | . – | . – |
| *Pinus mugo* | | . – | . – | . – | . – | 8 – | . – |
| **Diagnostic field layer species ($E_1$)** | | | | | | | |
| *Ranunculus breyninus* | *** | **86** $^{91.3}$ | . – | . – | . – | . – | . – |
| *Campanula cochleariifolia* | *** | **79** $^{86.8}$ | . – | . – | . – | . – | . – |
| *Phyteuma orbiculare* | *** | **79** $^{84.4}$ | . – | . – | 4 – | . – | . – |
| *Crepis jacquinii* | *** | **71** $^{82.2}$ | . – | . – | . – | . – | . – |
| *Vaccinium vitis-idaea* | *** | **86** $^{75.4}$ | 8 – | . – | 14 – | 8 – | . – |
| *Carex ornithopoda* | *** | **57** $^{72.5}$ | . – | . – | . – | . – | . – |
| *Carex digitata* | *** | **79** $^{69.3}$ | 15 – | 17 – | . – | . – | . – |
| *Carex sempervirens* ssp. *tatrorum* | *** | **57** $^{61.8}$ | 15 – | . – | . – | . – | . – |
| *Carduus glaucinus* | *** | **64** $^{59.3}$ | 31 – | . – | . – | . – | . – |
| *Swertia perennis* | *** | 36 $^{56.3}$ | . – | . – | . – | . – | . – |
| *Tofieldia calyculata* | *** | **50** $^{56.1}$ | 15 – | . – | . – | . – | . – |
| *Maianthemum bifolium* | *** | **86** $^{54.4}$ | **54** $^{23.3}$ | 17 – | 7 – | . – | 17 – |
| *Clematis alpina* | *** | **79** $^{52.3}$ | 31 – | 33 – | 18 – | . – | . – |
| *Calamagrostis varia* | *** | **86** $^{51.4}$ | 54 – | 17 – | 29 – | 8 – | . – |
| *Poa alpina* | *** | 43 $^{50.4}$ | 8 – | . – | 7 – | . – | . – |
| *Festuca tatrae* | ** | 36 $^{46.4}$ | 8 – | . – | 4 – | . – | . – |
| *Orthilia secunda* | ** | 29 $^{46.1}$ | . – | . – | 4 – | . – | . – |
| *Campanula rotundifolia* agg. | ** | 43 $^{43.7}$ | . – | . – | 4 – | 23 – | . – |
| *Fragaria vesca* | *** | **79** $^{41.5}$ | 15 – | 67 – | 46 – | . – | . – |
| *Galium anisophyllon* | * | 21 $^{38.6}$ | . – | . – | 4 – | . – | . – |
| *Lathyrus vernus* | * | 21 $^{34.5}$ | 8 – | . – | . – | . – | . – |

| Group No. | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| *Aquilegia vulgaris* | ** | 36 $^{33.9}$ | . $^{-}$ | 33 $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Corallorrhiza trifida* | * | 29 $^{31.8}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 23 $^{-}$ | . $^{-}$ |
| *Melica nutans* | ** | 29 $^{31.1}$ | 8 $^{-}$ | 17 $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Polygonatum verticillatum* | * | **93** $^{31.1}$ | 77 $^{-}$ | **67** $^{-}$ | **68** $^{-}$ | 31 $^{-}$ | 17 $^{-}$ |
| *Gymnocarpium robertianum* | * | 29 $^{30.0}$ | 23 $^{-}$ | . $^{-}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Homogyne alpina* | * | **100** $^{27.7}$ | **77** $^{-}$ | 17 $^{-}$ | **79** $^{-}$ | **62** $^{-}$ | **100** $^{-}$ |
| *Astrantia major* | * | **71** $^{25.0}$ | **69** $^{-}$ | **67** $^{-}$ | 39 $^{-}$ | 15 $^{-}$ | . $^{-}$ |
| *Cystopteris montana* | *** | . $^{-}$ | **54** $^{70.2}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Dentaria enneaphyllos* | *** | 21 $^{-}$ | **85** $^{69.7}$ | 17 $^{-}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Rubus saxatilis* | *** | 43 $^{23.6}$ | **77** $^{60.9}$ | . $^{-}$ | . $^{-}$ | 8 $^{-}$ | . $^{-}$ |
| *Festuca carpathica* | *** | . $^{-}$ | 38 $^{58.5}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Asplenium viride* | *** | **57** $^{-}$ | **92** $^{53.4}$ | 33 $^{-}$ | 29 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Ranunculus nemorosus* | *** | . $^{-}$ | 31 $^{52.0}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Laserpitium latifolium* | ** | . $^{-}$ | 31 $^{48.2}$ | . $^{-}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Cortusa matthioli* | *** | **64** $^{-}$ | **100** $^{47.1}$ | **67** $^{-}$ | **54** $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Allium victorialis* | *** | . $^{-}$ | 38 $^{45.3}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 17 $^{-}$ |
| *Crepis paludosa* | *** | 43 $^{-}$ | **85** $^{45.1}$ | **50** $^{-}$ | 39 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Trollius altissimus* | ** | . $^{-}$ | 23 $^{44.7}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Mercurialis perennis* | *** | **57** $^{19.1}$ | **85** $^{44.6}$ | **67** $^{-}$ | 4 $^{-}$ | 8 $^{-}$ | . $^{-}$ |
| *Viola biflora* | *** | **64** $^{-}$ | **92** $^{43.5}$ | 17 $^{-}$ | **50** $^{-}$ | 8 $^{-}$ | 33 $^{-}$ |
| *Geranium sylvaticum* | *** | 43 $^{-}$ | **85** $^{41.3}$ | **50** $^{-}$ | 43 $^{-}$ | . $^{-}$ | 17 $^{-}$ |
| *Poa stiriaca* | ** | 29 $^{24.7}$ | 38 $^{38.7}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Veratrum album* ssp. *lobelianum* | ** | 36 $^{-}$ | **77** $^{38.6}$ | . $^{-}$ | 54 $^{-}$ | 31 $^{-}$ | 17 $^{-}$ |
| *Campanula serrata* | *** | . $^{-}$ | 46 $^{36.7}$ | 17 $^{-}$ | . $^{-}$ | . $^{-}$ | 33 $^{-}$ |
| *Cyanus mollis* | * | . $^{-}$ | 15 $^{36.3}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Symphytum tuberosum* | * | . $^{-}$ | 15 $^{36.3}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Saxifraga rotundifolia* | * | . $^{-}$ | 15 $^{36.3}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Primula elatior* | ** | **64** $^{-}$ | **100** $^{35.6}$ | **83** $^{-}$ | **64** $^{-}$ | 38 $^{-}$ | 17 $^{-}$ |
| *Gentiana asclepiadea* | ** | **64** $^{-}$ | **92** $^{32.8}$ | **83** $^{-}$ | **57** $^{-}$ | 38 $^{-}$ | . $^{-}$ |
| *Melampyrum sylvaticum* | ** | 43 $^{19.4}$ | **54** $^{30.9}$ | 33 $^{-}$ | . $^{-}$ | 15 $^{-}$ | . $^{-}$ |
| *Geum rivale* | * | 7 $^{-}$ | 38 $^{30.3}$ | 17 $^{-}$ | 25 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Phyteuma spicatum* | * | **71** $^{-}$ | **85** $^{28.8}$ | **67** $^{-}$ | 54 $^{-}$ | 38 $^{-}$ | . $^{-}$ |
| *Actaea spicata* | ** | . $^{-}$ | . $^{-}$ | **50** $^{56.8}$ | 14 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Aconitum variegatum* | ** | 14 $^{-}$ | 8 $^{-}$ | **67** $^{54.5}$ | 25 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Digitalis grandiflora* | ** | . $^{-}$ | . $^{-}$ | 33 $^{54.2}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Polypodium vulgare* | ** | . $^{-}$ | . $^{-}$ | 33 $^{54.2}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Polystichum aculeatum* | * | . $^{-}$ | . $^{-}$ | 33 $^{50.6}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Geranium robertianum* | * | . $^{-}$ | . $^{-}$ | 33 $^{50.6}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Dryopteris filix-mas* | ** | 14 $^{-}$ | 46 $^{-}$ | **100** $^{45.9}$ | **57** $^{-}$ | 8 $^{-}$ | **67** $^{-}$ |
| *Campanula trachelium* | * | . $^{-}$ | 8 $^{-}$ | 33 $^{44.2}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Campanula persicifolia* | * | 7 $^{-}$ | 8 $^{-}$ | 33 $^{41.6}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Delphinium elatum* | * | . $^{-}$ | 15 $^{-}$ | 33 $^{39.0}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Doronicum austriacum* | *** | . $^{-}$ | 8 $^{-}$ | . $^{-}$ | **64** $^{67.2}$ | 8 $^{-}$ | . $^{-}$ |
| *Leucanthemum rotundifolium* | *** | 29 $^{-}$ | 23 $^{-}$ | 17 $^{-}$ | **82** $^{58.9}$ | . $^{-}$ | . $^{-}$ |
| *Milium effusum* | *** | 7 $^{-}$ | 15 $^{-}$ | . $^{-}$ | **50** $^{52.0}$ | . $^{-}$ | . $^{-}$ |
| *Cicerbita alpina* | *** | 7 $^{-}$ | 38 $^{-}$ | 33 $^{-}$ | **82** $^{49.9}$ | 23 $^{-}$ | . $^{-}$ |
| *Dentaria glandulosa* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | 21 $^{43.0}$ | . $^{-}$ | . $^{-}$ |

| Group No. | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| *Sesleria tatrae* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | 18 $^{39.2}$ | . $^{-}$ | . $^{-}$ |
| *Arabis alpina* | * | . $^{-}$ | . $^{-}$ | . $^{-}$ | 14 $^{34.9}$ | . $^{-}$ | . $^{-}$ |
| *Oreogeum montanum* | * | . $^{-}$ | . $^{-}$ | . $^{-}$ | 14 $^{34.9}$ | . $^{-}$ | . $^{-}$ |
| *Aconitum firmum* | ** | 7 $^{-}$ | 15 $^{-}$ | . $^{-}$ | 29 $^{32.1}$ | . $^{-}$ | . $^{-}$ |
| *Epilobium montanum* | *** | 14 $^{-}$ | 8 $^{-}$ | **67** $^{-}$ | **64** $^{30.8}$ | 23 $^{-}$ | 17 $^{-}$ |
| *Geranium palustre* | * | . $^{-}$ | . $^{-}$ | . $^{-}$ | 11 $^{30.2}$ | . $^{-}$ | . $^{-}$ |
| *Adenostyles alliariae* | *** | 43 $^{-}$ | 46 $^{-}$ | **67** $^{-}$ | **96** $^{28.6}$ | **62** $^{-}$ | **83** $^{-}$ |
| *Chrysosplenium alternifolium* | ** | . $^{-}$ | 23 $^{-}$ | 17 $^{-}$ | 39 $^{28.5}$ | . $^{-}$ | 17 $^{-}$ |
| *Galeobdolon luteum* agg. | ** | 21 $^{-}$ | **54** $^{-}$ | **50** $^{-}$ | **68** $^{26.9}$ | 38 $^{-}$ | . $^{-}$ |
| *Veronica officinalis* | * | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 15 $^{36.3}$ | . $^{-}$ |
| *Soldanella carpatica* | ** | 36 $^{-}$ | 31 $^{-}$ | . $^{-}$ | 18 $^{-}$ | **69** $^{33.3}$ | **50** $^{-}$ |
| *Agrostis capillaris* | *** | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | **83** $^{\mathbf{89.8}}$ |
| *Calamagrostis villosa* | *** | . $^{-}$ | 31 $^{-}$ | . $^{-}$ | 25 $^{-}$ | 31 $^{-}$ | **100** $^{\mathbf{66.6}}$ |
| *Luzula luzuloides* | *** | 29 $^{-}$ | . $^{-}$ | 33 $^{-}$ | 25 $^{-}$ | . $^{-}$ | **100** $^{\mathbf{66.5}}$ |
| *Deschampsia cespitosa* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | 7 $^{-}$ | 8 $^{-}$ | **50** $^{\mathbf{56.5}}$ |
| *Veronica chamaedrys* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 33 $^{\mathbf{54.2}}$ |
| *Ranunculus repens* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 33 $^{\mathbf{54.2}}$ |
| *Poa annua* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 33 $^{\mathbf{54.2}}$ |
| *Anthoxanthum odoratum* | ** | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | 33 $^{\mathbf{54.2}}$ |
| *Rubus idaeus* | ** | 7 $^{-}$ | 8 $^{-}$ | **67** $^{-}$ | **57** $^{11.0}$ | 31 $^{-}$ | **100** $^{49.5}$ |
| *Athyrium filix-femina* | ** | 14 $^{-}$ | 15 $^{-}$ | 17 $^{-}$ | 39 $^{-}$ | 23 $^{-}$ | **83** $^{49.2}$ |
| *Dryopteris carthusiana* agg. | * | 14 $^{-}$ | 31 $^{-}$ | 33 $^{-}$ | **71** $^{20.9}$ | 38 $^{-}$ | **100** $^{46.5}$ |
| **Diagnostic field layer species for two or more associations** | | | | | | | |
| *Sesleria caerulea* | $\underline{***}$ | **100** $^{\underline{\mathbf{69.2}}}$ | **77** $^{\underline{46.5}}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Bellidiastrum michelii* | $\underline{***}$ | **93** $^{\underline{\mathbf{66.5}}}$ | **62** $^{34.9}$ | . $^{-}$ | 7 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Pimpinella major* | $\underline{***}$ | **64** $^{\underline{48.9}}$ | 46 $^{28.8}$ | . $^{-}$ | 4 $^{-}$ | 8 $^{-}$ | . $^{-}$ |
| *Soldanella marmarossiensis* agg. | $\underline{**}$/* | **79** $^{\underline{38.4}}$ | 31 $^{-}$ | 33 $^{-}$ | **64** $^{25.2}$ | 15 $^{-}$ | . $^{-}$ |
| *Heracleum sphondylium* | $\underline{***}$ | **79** $^{35.8}$ | **100** $^{\underline{\mathbf{55.4}}}$ | 33 $^{-}$ | 25 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Cardaminopsis arenosa* agg. | $\underline{***}$ | **64** $^{34.1}$ | **92** $^{\underline{\mathbf{61.6}}}$ | 17 $^{-}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Cirsium erisithales* | $\underline{***}$ | **86** $^{\underline{33.9}}$ | **100** $^{\underline{46.7}}$ | **83** $^{-}$ | 18 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Valeriana tripteris* | $\underline{**}$ | **100** $^{\underline{32.3}}$ | **100** $^{\underline{32.3}}$ | **100** $^{-}$ | **71** $^{-}$ | 23 $^{-}$ | . $^{-}$ |
| *Mycelis muralis* | ** | **71** $^{26.7}$ | 15 $^{-}$ | **67** $^{-}$ | 21 $^{-}$ | **77** $^{31.7}$ | . $^{-}$ |
| *Polystichum lonchitis* | $\underline{**}$/* | **64** $^{26.3}$ | **69** $^{\underline{30.9}}$ | **50** $^{-}$ | 25 $^{-}$ | 8 $^{-}$ | . $^{-}$ |
| *Pyrethrum clusii* | $\underline{***}$/* | 36 $^{-}$ | **69** $^{\underline{37.8}}$ | **67** $^{35.3}$ | 11 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Tithymalus amygdaloides* | $\underline{***}$/* | . $^{-}$ | 46 $^{\underline{35.5}}$ | **50** $^{40.1}$ | 4 $^{-}$ | . $^{-}$ | . $^{-}$ |
| *Chaerophyllum hirsutum* | $\underline{**}$/* | 21 $^{-}$ | **62** $^{32.2}$ | 17 $^{-}$ | **57** $^{\underline{27.9}}$ | . $^{-}$ | 17 $^{-}$ |
| *Galium schultesii* | $\underline{**}$/* | 36 $^{-}$ | **69** $^{\underline{29.3}}$ | 83 $^{42.3}$ | 21 $^{-}$ | 15 $^{-}$ | . $^{-}$ |
| *Stellaria nemorum* | $\underline{***}$/** | . $^{-}$ | 15 $^{-}$ | . $^{-}$ | **68** $^{\underline{34.6}}$ | 8 $^{-}$ | **100** $^{\mathbf{65.5}}$ |
| *Calamagrostis arundinacea* | $\underline{***}$/* | **86** $^{\underline{30.2}}$ | 23 $^{-}$ | 83 $^{28.1}$ | 29 $^{-}$ | 8 $^{-}$ | **83** $^{28.1}$ |
| **Other field layer species ($E_1$)** | | | | | | | |
| *Oxalis acetosella* | | **79** $^{-}$ | **69** $^{-}$ | **83** $^{-}$ | **96** $^{14.0}$ | **85** $^{-}$ | **100** $^{-}$ |
| *Luzula sylvatica* ssp. *sylvatica* | | **86** $^{-}$ | **100** $^{22.7}$ | **67** $^{-}$ | **79** $^{-}$ | 46 $^{-}$ | **100** $^{-}$ |
| *Senecio nemorensis* agg. | | **50** $^{-}$ | **54** $^{-}$ | **100** $^{-}$ | **96** $^{19.9}$ | **85** $^{-}$ | **83** $^{-}$ |
| *Vaccinium myrtillus* | | **93** $^{-}$ | **92** $^{-}$ | . $^{-}$ | **64** $^{-}$ | **77** $^{-}$ | **100** $^{-}$ |
| *Hieracium murorum* | | **86** $^{17.9}$ | **77** $^{-}$ | **67** $^{-}$ | **50** $^{-}$ | 38 $^{-}$ | **83** $^{-}$ |
| *Prenanthes purpurea* | | **71** $^{-}$ | **69** $^{-}$ | **67** $^{-}$ | **57** $^{-}$ | **54** $^{-}$ | 33 $^{-}$ |
| *Myosotis sylvatica* | | 21 $^{-}$ | 46 $^{-}$ | **67** $^{-}$ | **75** $^{19.3}$ | **62** $^{-}$ | **50** $^{-}$ |

| Group No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| *Avenella flexuosa* | **57**$^{-}$ | 8$^{-}$ | 33$^{-}$ | **57**$^{-}$ | 38$^{-}$ | **50**$^{-}$ |
| *Ranunculus platanifolius* | 7$^{-}$ | **54**$^{-}$ | **50**$^{-}$ | **54**$^{21.5}$ | 23$^{-}$ | .$^{-}$ |
| *Solidago virgaurea* | 36$^{-}$ | 15$^{-}$ | 17$^{-}$ | 43$^{22.1}$ | 23$^{-}$ | .$^{-}$ |
| *Athyrium distentifolium* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 39$^{14.3}$ | 46$^{-}$ | **50**$^{-}$ |
| *Senecio subalpinus* | 14$^{-}$ | 31$^{-}$ | 17$^{-}$ | 39$^{20.2}$ | 8$^{-}$ | 17$^{-}$ |
| *Lilium martagon* | 43$^{-}$ | 38$^{-}$ | 33$^{-}$ | 14$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Thalictrum aquilegiifolium* | 7$^{-}$ | 23$^{-}$ | **50**$^{-}$ | 39$^{21.7}$ | .$^{-}$ | .$^{-}$ |
| *Paris quadrifolia* | 14$^{-}$ | 15$^{-}$ | 17$^{-}$ | 36$^{23.6}$ | 15$^{-}$ | .$^{-}$ |
| *Ranunculus lanuginosus* | .$^{-}$ | 23$^{-}$ | **50**$^{-}$ | 32$^{15.2}$ | 8$^{-}$ | .$^{-}$ |
| *Moneses uniflora* | 29$^{-}$ | 8$^{-}$ | 17$^{-}$ | 18$^{-}$ | 31$^{-}$ | .$^{-}$ |
| *Acetosa arifolia* | .$^{-}$ | 15$^{-}$ | .$^{-}$ | 29$^{-}$ | 8$^{-}$ | **50**$^{-}$ |
| *Alchemilla* sp. div. | .$^{-}$ | .$^{-}$ | .$^{-}$ | 36$^{24.9}$ | 8$^{-}$ | **50**$^{-}$ |
| *Gymnocarpium dryopteris* | 21$^{-}$ | 31$^{-}$ | .$^{-}$ | 21$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Cystopteris fragilis* | .$^{-}$ | 8$^{-}$ | 33$^{-}$ | 25$^{20.0}$ | .$^{-}$ | .$^{-}$ |
| *Hypericum maculatum* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 18$^{-}$ | 8$^{-}$ | 33$^{-}$ |
| *Pulmonaria obscura* | .$^{-}$ | 23$^{-}$ | 17$^{-}$ | 14$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Silene dioica* | .$^{-}$ | 23$^{-}$ | 17$^{-}$ | 14$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Valeriana sambucifolia* | .$^{-}$ | 8$^{-}$ | 33$^{-}$ | 18$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Huperzia selago* | .$^{-}$ | 8$^{-}$ | 17$^{-}$ | 21$^{23.2}$ | .$^{-}$ | .$^{-}$ |
| *Cardamine impatiens* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 14$^{-}$ | 23$^{-}$ | .$^{-}$ |
| *Petasites albus* | 14$^{-}$ | 8$^{-}$ | 17$^{-}$ | 11$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Urtica dioica* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 18$^{14.9}$ | .$^{-}$ | 17$^{-}$ |
| *Cardaminopsis halleri* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 14$^{-}$ | 23$^{-}$ | .$^{-}$ |
| *Phegopteris connectilis* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 11$^{-}$ | .$^{-}$ | 33$^{-}$ |
| *Anthriscus nitidus* | .$^{-}$ | .$^{-}$ | 33$^{-}$ | 14$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Asarum europaeum* | .$^{-}$ | 8$^{-}$ | 17$^{-}$ | 4$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Poa nemoralis* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 7$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Angelica sylvestris* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Hieracium prenanthoides* | .$^{-}$ | 8$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Aegopodium podagraria* | .$^{-}$ | 8$^{-}$ | .$^{-}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Coeloglossum viride* | .$^{-}$ | 8$^{-}$ | .$^{-}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Geranium phaeum* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | .$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Lunaria rediviva* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Festuca picturata* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Potentilla aurea* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | .$^{-}$ | 17$^{-}$ |
| *Aruncus dioicus* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Tussilago farfara* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | .$^{-}$ | 17$^{-}$ |
| *Circaea alpina* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 4$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Adoxa moschatellina* | .$^{-}$ | .$^{-}$ | .$^{-}$ | 4$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Convallaria majalis* | 7$^{-}$ | .$^{-}$ | 17$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Galium odoratum* | .$^{-}$ | 8$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 17$^{-}$ |
| *Campanula rapunculoides* | .$^{-}$ | 8$^{-}$ | 17$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Stachys alpina* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Hylotelephium argutum* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Ajuga reptans* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Galeopsis speciosa* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | .$^{-}$ | .$^{-}$ | 17$^{-}$ |
| *Polygonatum odoratum* | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |

| Group No. | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| *Dentaria bulbifera* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Phleum rhaeticum* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 8$^{-}$ | 17$^{-}$ |
| **Diagnostic ground layer species (E$_0$)** | | | | | | | |
| *Ctenidium molluscum* | *** | **79** $^{56.1}$ | 31$^{-}$ | 17$^{-}$ | 21$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Mnium spinosum* | *** | **93** $^{55.7}$ | 8$^{-}$ | 33$^{-}$ | 46$^{-}$ | 23$^{-}$ | .$^{-}$ |
| *Pleurozium schreberi* | ** | **50** $^{48.4}$ | 15$^{-}$ | .$^{-}$ | 14$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Dicranum scoparium* | *** | **100** $^{43.2}$ | 31$^{-}$ | 33$^{-}$ | **64**$^{-}$ | 15$^{-}$ | **67**$^{-}$ |
| *Rhytidiadelphus loreus* | * | 14 $^{34.9}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Tortella tortuosa* | ** | **64** $^{34.9}$ | **54** $^{24.6}$ | 33$^{-}$ | 14$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Plagiothecium curvifolium* | ** | **64** $^{31.9}$ | 15$^{-}$ | .$^{-}$ | 18$^{-}$ | 23$^{-}$ | **67**$^{-}$ |
| *Hylocomium splendens* | * | **57** $^{29.5}$ | 31$^{-}$ | 33$^{-}$ | 21$^{-}$ | 23$^{-}$ | .$^{-}$ |
| *Plagiochila asplenioides* | * | 36 $^{25.7}$ | 23$^{-}$ | 17$^{-}$ | .$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Cirriphyllum tommasinii* | * | .$^{-}$ | 15 $^{36.3}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Eurhynchium angustirete* | ** | .$^{-}$ | 8$^{-}$ | **50** $^{56.5}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Hypnum cupressiforme* | ** | .$^{-}$ | .$^{-}$ | 33 $^{54.2}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Plagiothecium laetum* | * | .$^{-}$ | .$^{-}$ | 33 $^{50.6}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Conocephalum conicum* | ** | .$^{-}$ | .$^{-}$ | .$^{-}$ | 21 $^{43.0}$ | .$^{-}$ | .$^{-}$ |
| *Cirriphyllum piliferum* | ** | .$^{-}$ | .$^{-}$ | .$^{-}$ | 21 $^{43.0}$ | .$^{-}$ | .$^{-}$ |
| *Rhytidiadelphus squarrosus* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 14 $^{34.9}$ | .$^{-}$ | .$^{-}$ |
| *Barbilophozia lycopodioides* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 11 $^{30.2}$ | .$^{-}$ | .$^{-}$ |
| *Drepanocladus uncinatus* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 11 $^{30.2}$ | .$^{-}$ | .$^{-}$ |
| *Fissidens taxifolius* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 11 $^{30.2}$ | .$^{-}$ | .$^{-}$ |
| *Plagiochila porelloides* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 11 $^{30.2}$ | .$^{-}$ | .$^{-}$ |
| *Brachythecium salebrosum* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 11 $^{30.2}$ | .$^{-}$ | .$^{-}$ |
| *Sphagnum girgensohnii* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | 4$^{-}$ | 23 $^{40.5}$ | .$^{-}$ |
| *Plagiothecium cavifolium* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 15 $^{36.3}$ | .$^{-}$ |
| *Mnium spinulosum* | * | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 15 $^{36.3}$ | .$^{-}$ |
| *Polytrichum formosum* | *** | 7$^{-}$ | .$^{-}$ | .$^{-}$ | 21$^{-}$ | 15$^{-}$ | **83** $^{68.0}$ |
| *Pellia* sp. | *** | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | **50** $^{67.4}$ |
| *Polytrichum commune* | ** | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 33 $^{54.2}$ |
| **Other ground layer species (E$_0$)** | | | | | | | |
| *Rhytidiadelphus triquetrus* | | 36$^{-}$ | 38$^{-}$ | 17$^{-}$ | 21$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Rhizomnium punctatum* | | .$^{-}$ | 23$^{-}$ | 33$^{-}$ | 11$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Brachythecium velutinum* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | 11$^{-}$ | 23$^{-}$ | .$^{-}$ |
| *Blepharostoma trichophyllum* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 14 $^{18.5}$ | .$^{-}$ | .$^{-}$ |
| *Fissidens dubius* | | .$^{-}$ | 15$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Atrichum undulatum* | | .$^{-}$ | 8$^{-}$ | .$^{-}$ | .$^{-}$ | 15$^{-}$ | 17$^{-}$ |
| *Plagiothecium denticulatum* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Lepidozia reptans* | | 7$^{-}$ | 15$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Cladonia coniocraea* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 7$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Dicranella heteromalla* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | 17$^{-}$ |
| *Plagiomnium affine* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | .$^{-}$ | 15$^{-}$ | .$^{-}$ |
| *Plagiomnium cuspidatum* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Tetraphis pellucida* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | 7$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Calypogeia azurea* | | .$^{-}$ | 8$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 17$^{-}$ |
| *Plagiomnium undulatum* | | .$^{-}$ | .$^{-}$ | 17$^{-}$ | 4$^{-}$ | .$^{-}$ | .$^{-}$ |
| *Dicranum montanum* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | 4$^{-}$ | 8$^{-}$ | .$^{-}$ |
| *Plagiomnium rostratum* | | .$^{-}$ | .$^{-}$ | .$^{-}$ | .$^{-}$ | 8$^{-}$ | 17$^{-}$ |

### *Seslerio caeruleae-Piceetum abietis* Fajmonová 1978 nom. corr. et nom. cons. propos.

Nomenclatural type: Fajmonová (1978), tab. 1, rel. 6, holotype.

Original name: *Seslerio-Piceetum* (Fajmonová, 1978, p. 553), i.e. *Seslerio variae-Piceetum abietis* Fajmonová 1978 nom. inept. (Rec. 10C, Art. 44)

Non: *Seslerio variae-Piceetum* Eggler 1952, *Seslerio-Piceetum* Zukrigl 1973 nom. inval. (Art. 3b)

Set of the most important diagnostic species:

E$_1$: *Ranunculus breyninus*, *Campanula cochleariifolia*, *Phyteuma orbiculare*, *Crepis jacquinii*, *Vaccinium vitis-idaea*, *Carex ornithopoda*, *Carex digitata*, **Sesleria caerulea*, **Bellidiastrum michelii*, *Carex sempervirens* ssp. *tatrorum*, *Carduus glaucinus*, *Swertia perennis*, *Tofieldia calyculata*, *Maianthemum bifolium*, *Clematis alpina*, *Calamagrostis varia*, *Poa alpina*, **Pimpinella major*, *Festuca tatrae*, *Orthilia secunda*, *Campanula rotundifolia* agg., **Cardaminopsis arenosa* agg., **Calamagrostis arundinacea*.

Relevé data: Fajmonová (1978), tab. 1, rels. 1–13; Fajmonová (1986), tab. 1, rel. 5; see fig. 3.

The association was described for Western Carpathian natural supramontane (marginally also upper montane) Norway spruce phytocoenoses on the most extreme habitats developed over dolomites and limestones within the class *Vaccinio-Piceetea* (Fajmonová, 1978). Their canopy is considerably open (cover 50–70 [80]%), formed by dominant *Picea abies* and admixed *Sorbus aucuparia*. Other tree species could also participate in canopy species composition: *Acer pseudoplatanus*, *Larix decidua*, *Sorbus aria* and sparsely shrubby *Fagus sylvatica*. In the understorey are usually growing *Daphne mezereum*, *Lonicera nigra*, *Pinus mugo*, *Rosa pendulina*, exceptionally also *Salix silesiaca*.

High species diversity of the field layer along with considerable number of the highly constant species is a characteristic feature of the community stands. The field layer dominant is *Sesleria caerulea*, here and there mutually with *Calamagrostis varia*. The group of calcicoles has significant abundance (*Bellidiastrum michelii*, *Carduus glaucinus*, *Cirsium erisithales*, *Cortusa matthioli*, *Phyteuma orbiculare* etc.), including the species which indicate shallow soils or stony habitats (*Asplenium viride*, *Cardaminopsis arenosa* agg., *Carex sempervirens* ssp. *tatrorum*, *Crepis jacquinii*, *Festuca tatrae*, *Poa alpina*, *Ranunculus breyninus*, *Tofieldia calyculata*). Substantial importance has the group of species which in the higher mountain altitudes prefer habitats on calcareous rocks (*Astrantia major*, *Clematis alpina*, *Carex digitata*, *Crepis paludosa*, *Fragaria vesca*, *Heracleum sphondylium*, *Geranium sylvaticum*, *Mercurialis perennis*, *Phyteuma spicatum*, *Polygonatum verticillatum*, *Primula elatior*, *Valeriana tripteris* and many others).

With high constancy in the stands are also growing *Calamagrostis arundinacea*, *Maianthemum bifolium*, *Luzula sylvatica* ssp. *sylvatica*, *Soldanella marmarossiensis* agg., *Prenanthes purpurea*, *Oxalis acetosella* or *Homogyne alpina*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Avenella flexuosa*. Species as *Viola biflora*, *Adenostyles alliariae*, *Melampyrum sylvaticum*, *Senecio nemorensis* agg. (Fajmonová 1978 ut *S. *jacquinianus* and *S. fuchsii*), *Leucanthemum rotundifolium* also frequently participate in the species composition of the phytocoenoses.

The most frequent ground layer species are *Ctenidium molluscum*, *Dicranum scoparium*, *Mnium spinosum*, *Plagiothecium curvifolium* and *Tortella tortuosa*. With a lower constancy are present e.g. *Hylocomium splendens* and *Pleurozium schreberi*.

*Variability.* – Due to low total number of recorded relevés, variability of the association *Seslerio caeruleae-Piceetum* Fajmonová 1978 is still insufficiently known. Therefore only variants are syntaxonomically recognized here:

(1) ***Aquilegia vulgaris*-variant** (diferential species: *Aquilegia vulgaris*, *Gentiana asclepiadea*, *Moneses uniflora*, *Pimpinella major*, *Tofieldia calyculata*, data: Fajmonová (1978), tab. 1. rel. 1, 2, 6–10);

(2) ***Pyrethrum clusii*-variant** (diferential species: *Galium schultesii*, *Lilium martagon*, *Melampyrum sylvaticum*, *Poa stiriaca*, *Pyrethrum clusii*, *Rubus saxatilis*; data: Fajmonová 1978, tab. 1. rel. 4, 5, 12, 13, Fajmonová (1986), tab. 1. rel. 5);

(3) ***Paris quadrifolia*-variant** (differential species *Dentaria enneaphyllos*, *Dryopteris dilatata*, *Galeobdolon luteum* agg., *Lathyrus vernus*, *Paris quadrifolia*, data: Fajmonová (1978), tab. 1. rel. 3, 11) with differential species indicating less extreme habitat conditions, however, dominance of *Sesleria caerulea* is maintained.

*Nomenclatural note.* – According to the taxonomical reassessments in the genus *Sesleria* (Foggi et al., 2001), the name *Sesleria varia* (Jacq.) Wettst. used by Fajmonová (1978) is a later synonym of the correct name *Sesleria caerulea* (L.) Ard. Since the name *S. caerulea* (L.) Ard. is accepted in the newer botanical literature (Kubát et al., 2002; Fischer et al., 2008; Tisson et al., 2014; Jäger et al., 2017; Kaplan et al., 2019; Mereďa et al., 2019; etc.), formal change of the original name *Seslerio variae-Piceetum* Fajmonová 1978 is here proposed.

The name *Seslerio variae-Piceetum* Fajmonová 1978 is a later homonym of the validly published name *Seslerio* *variae-Piceetum* Eggler 1952 (see also the syntaxonomical note). However, the latter name was never accepted by later Austrian authors (Wallnöfer, 1993, p. 320; Exner, 2007, p. 191; Willner, 2007, p. 238) and Willner (2007, p. 238) proposed to give the nomenclatural priority to its later syntaxonomical synonym *Adenostylo glabrae-Piceetum* Zukrigl 1973. Recent Slovenian authors seem to accept the name "*Seslerio variae-Piceetum* Eggler 1952", though only one relevé is known from Slovenia (Zupančič, 1999, tab. 17) and it represent floristically and ecologically different community from *Seslerio variae-Piceetum* Eggler 1952; according to Zupančič the phytocoenosis represent a secondary Norway spruce community (cf. Šilc & Čarni, 2012; Juvan et al., 2013).

On the contrary, the name *Seslerio variae-Piceetum* Fajmonová 1978 was immediately accepted in the Slovak literature for the respective natural supramontane(-montane) Norway spruce community (Šomšák in Mucina et al., 1985) and was continuously used to the present (Jarolímek et al., 2008a; Kučera, 2010a; Kučera, 2012a). To avoid an inconvenient rejection of this commonly used name, it is formally proposed for protection as a nomen conservandum (cf. Kučera, 2012a, p. 210), with consideration of the required nomenclatural change to *Seslerio caerulae-Piceetum* Fajmonová 1978 nom. corr.

*Syntaxonomical note*. – Phytocoenoses documented by Eggler (1952) and Zupančič (1999) does not belong to *Seslerio caerulae-Piceetum* Fajmonová 1978 due to a different phytochorological and/or ecological content (e.g. species *Adenostyles glabra*, *Galium verum*, *Pulmonaria stiriaca*, *Soldanella alpina*, different abundances of *Fragaria vesca*, *Poa stiriaca*, *Oxalis aceotsella*, *valeriana tripteris* etc. as recorded by Eggler; or *Erica carnea*, *Cyclamen purpurascens*, *Helleborus niger* ssp. *niger*, *Polygala chamaebuxus etc.* recorded by Zupančič). Moreover, the phytocoenoses of Fajmonová (1978) represent ecologically most extreme natural calcicolous Norway spruce community of the Western Carpathians, while the relevés of *Seslerio-Piceetum poetosum stiriacae* of Eggler (1952) reflect mostly secondary Norway spruce stands from the Austrian Eastern Alps (cf. Eggler, 1952, p. 39).

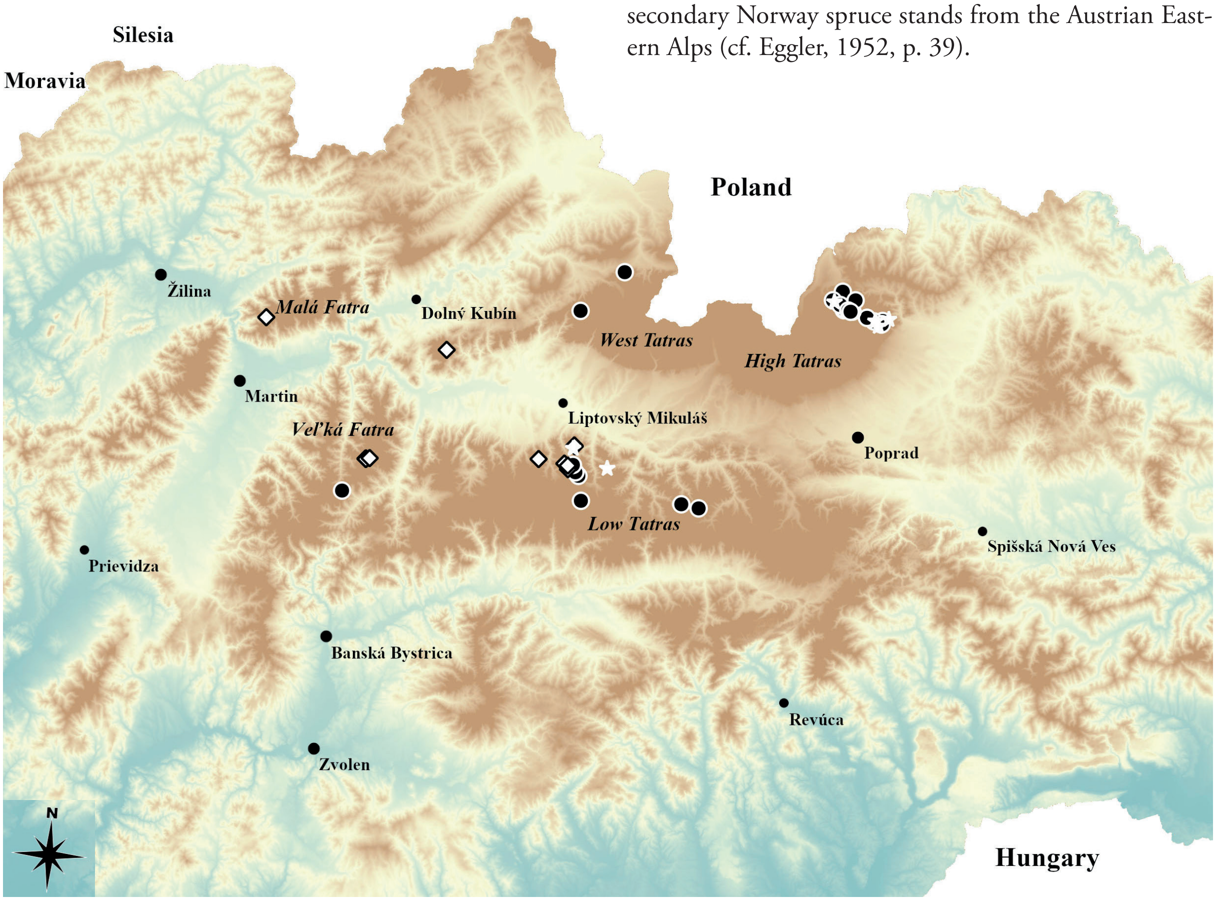

**Figure 2:** Distribution of analysed associations' relevés in Slovakia: diamonds – *Cirsio erisithalis-Piceetum*, stars – *Fragario vescae-Piceetum*, circles – *Adenostylo alliariae-Piceetum*. Made with QGIS.

**Slika 2:** Razširjenost popisov obravnavanih asociacij na Slovaškem: diamanti – *Cirsio erisithalis-Piceetum*, zvezde – *Fragario vescae-Piceetum*, krogi – *Adenostylo alliariae-Piceetum*. Narejeno z QGIS.

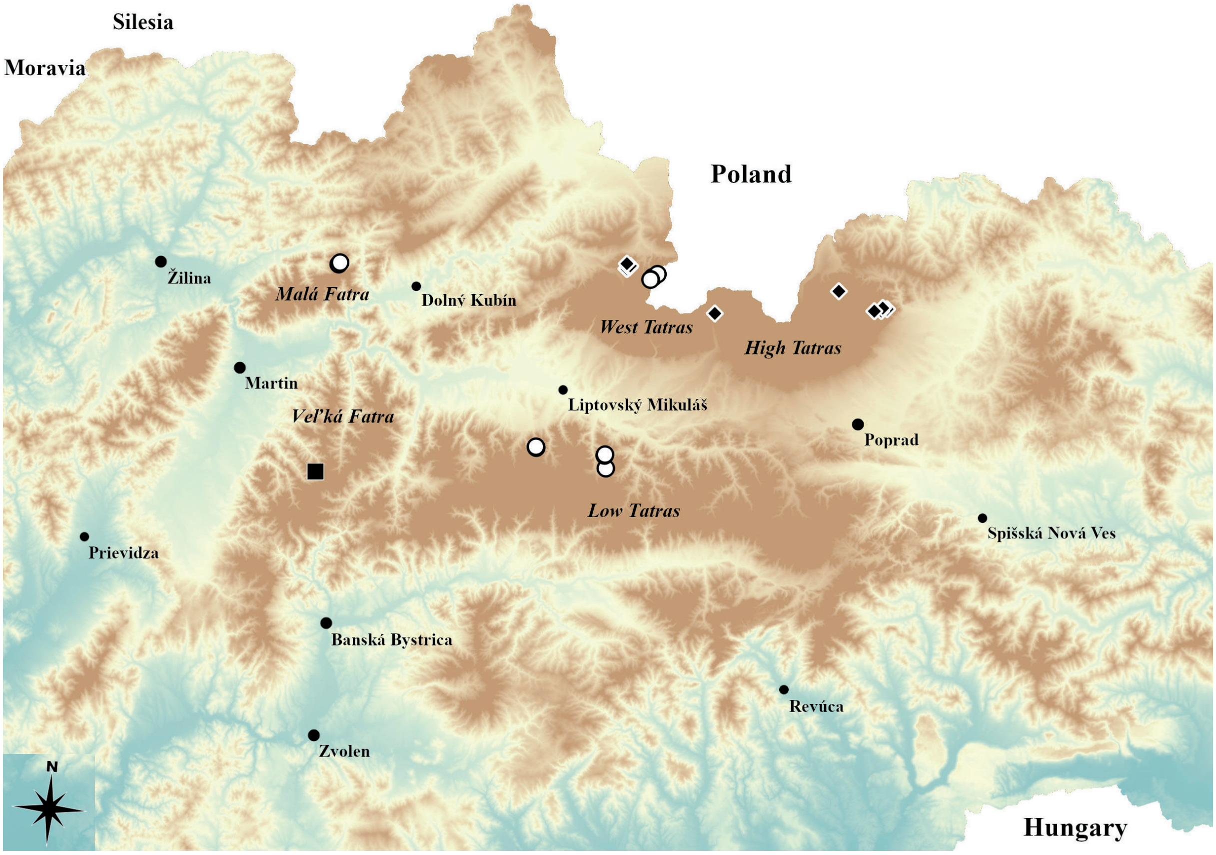

**Figure 3:** Distribution of analysed associations' relevés in Slovakia: circles – *Seslerio caeruleae-Piceetum*, diamonds – *Mnio spinosi-Piceetum*, squares (overlapping) – *Hieracio murorum-Piceetum.* Made with QGIS.

**Slika 3:** Razširjenost popisov obravnavanih asociacij na Slovaškem: krogi – *Seslerio caeruleae-Piceetum*, diamanti – *Mnio spinosi-Piceetum*, kvadrati (se prekrivajo) – *Hieracio murorum-Piceetum.* Narejeno z QGIS.

## *Cirsio erisithalis-Piceetum abietis* Fajmonová et P. Kučera ass. nov. hoc loco

Nomenclatural type: Fajmonová (1986), tab. 1, rel. 11, holotypus hoc loco.

Incl.: *Piceetum excelsae altherbosum calcicolum* Sillinger 1933 subtyp *Oxalis* p. p., *Sorbo-Piceetum calcicolum* Šmarda et al. 1971 facies *calamagrostietosum* p. p. min., *Cortuso-Piceetum calamagrostietosum variae* sensu Fajmonová 1986 non (Šoltés 1976) Fajmonová 1986, *Cortuso-Piceetum typicum* (sensu Fajmonová 1986), *Cortuso-Piceetum saxifragetosum rotundifolii* Fajmonová 1986, *Cortuso-Piceetum adenostyletosum alliariae* Fajmonová 1986

Pseud.: *Cortuso-Piceetum* sensu Fajmonová 1978 non (Šoltés 1976) Fajmonová 1978 p. p. min., *Cortuso-Piceetum* sensu Fajmonová 1986 non (Šoltés 1976) Fajmonová 1978

Non: *Piceetum excelsae normale calcicolum* Sillinger 1933 nom. illeg. (Art. 34a), *Adenostylo alliariae-Piceetum cortusetosum* Šoltés 1976

Set of the most important diagnostic species:

$E_1$: *Cystopteris montana*, *Dentaria enneaphyllos*, **Cardaminopsis arenosa* agg., *Rubus saxatilis*, *Festuca carpathica*, *Asplenium viride*, *Ranunculus nemorosus*, *Laserpitium latifolium*, **Sesleria caerulea*, *Allium victorialis*, **Tithymalus amygdaloides*, **Bellidiastrum michelii*, **Chaerophyllum hirsutum*, **Galium schultesii*, **Pimpinella major*.

Relevé data and original diagnosis: Fajmonová (1986), tab. 1, rels. 1–4, 11, 13, 15–17, 21, 23–25; see fig. 2.

Supramontane *Picea abies* woodland of less extreme habitats of limestones and dolomites (in comparison to *Seslerio-Piceetum* Fajmonová 1978), however, the slopes are still steep ([15] 25–30°) and, consequently, canopy cover is considerably open (55–75 [80]%). *Sorbus aucuparia* is a constant companion of Norway spruce, admixed tree species are *Acer pseudoplatanus* (often), *S. aria* (occasionally) and *Fagus sylvatica* (only exceptionally and then with a low growth). *Daphne mezereum* is a constant species of the understorey, less frequently is growing *Salix* *silesiaca*, here and there are present also *Pinus mugo*, *Lonicera nigra* and *Ribes petraeum*.

The field layer is usually dominated by *Cortusa matthioli*, frequently accompanied by *Luzula sylvatica* ssp. *sylvatica*. Habitats with moderately shallow but very skeleton-rich soils, for example rocky slopes and ridges, induce opening of canopy cover and *Calamagrostis varia* dominates in the field cover. An ecological opposite constitutes the sub-community with *Adenostyles alliariae* or *Saxifraga rotundifolia* as codominant species (cover up to ca. 25%) to *Cortusa*.

Equally as in the case of *Seslerio-Piceetum* Fajmonová 1978, very species rich composition of this community consists of numerous species with high constancy and many less frequent species. Characteristic features are the group of calcicoles (in addition to *Cortusa* and *Calamagrostis varia* for example *Cirsium erisithales*, *Asplenium viride*, *Cardaminopsis arenosa* agg., *Sesleria albicans*, *Bellidiastrum michelii*) and very abundant group of species which prefer calcareous soils in higher mountain altitudes (*Astrantia major*, *Crepis paludosa*, *Galium schultesii*, *Geranium sylvaticum*, *Heracleum sphondylium*, *Hieracium murorum*, *Phyteuma spicatum*, *Polygonatum verticillatum*, *Primula elatior*, *Valeriana tripteris* and others).

The constant components of stands of the association are species commonly growing also in other types of natural Norway spruce communities: *Luzula sylvatica* ssp. *sylvatica*, *Vaccinium myrtillus*, *Gentiana asclepiadea*, *Homogyne alpina*, *Oxalis acetosella*, *Prenanthes purpurea*, *Senecio hercynicus* etc. (Kučera, 2012a). In the stands are usually with low cover but frequently growing also *Rubus saxatilis*, *Polystichum lonchitis*, *Chaerophyllum hirsutum*, *Tithymalus amygdaloides*; *Viola biflora*, *Dentaria enneaphyllos* and *Mercurialis perennis* could here and there reach cover over 5%.

Moss species are absent in some stands of the community. The most frequent ground layer species is *Tortella tortuosa*, with lower constancy are occurring especially *Ctenidium molluscum*, *Mnium spinosum*, *Rhizomnium punctatum*, along with common woodland moss species *Dicranum scoparium*, *Hylocomium splendens* and *Rhytidiadelphus triquetrus*.

*Variability*. – In dependence on the variability in habitat ecology and, consequently, field layer species composition as well as physiognomy, a series of sub-communities is differentiated following the soil shallowness and amount of soil skeleton:

(1) **subassociation *Cirsio erisithalis-Piceetum calamagrostietosum variae* Fajmonová et P. Kučera subass. nov. hoc loco** (nomenclatural type: Fajmonová (1986), tab. 1, rel. 4, holotypus hoc loco; differential species: *Calamagrostis varia* (dominant), *Carduus glaucinus*, *Laserpitium latifolium*, *Melampyrum sylvaticum*, *Pimpinella major*, *Pinus mugo*; original diagnosis: Fajmonová 1986, tab. 1, rels. 1–4) on the most extreme habitats within the association (see Fajmonová 1986, p. 50); this subcomunity corresponds to the unit differentiated by Fajmonová (1986) under the pseudonym *Cortuso-Piceetum calamagrostietosum variae* sensu Fajmonová 1986 non (Šoltés 1976) Fajmonová 1986;

(2) **subassociation *Cirsio erisithalis-Piceetum typicum* subass. nov. hoc loco** (nomenclatural type: Fajmonová (1986), tab. 1, rel. 11, holotypus hoc loco, automatical holotype sensu Art. 5b; differential species: *Campanula serrata*, *Geum rivale*, *Soldanella carpatica*; original diagnosis: Fajmonová (1986), tab. 1, rels. 11, 13, 16, 17) includes ecologically intermediate phytocoenoses within this association; this sub-community corresponds to the unit commonly used under the pseudonym *Cortuso-Piceetum typicum* sensu Fajmonová 1986 non (Šoltés 1976) Fajmonová 1986 and included are also phytocoenoses of natural Norway spruce woodland classified as *Cortuso-Piceetum saxifragetosum rotundifolii* Fajmonová 1986;

(3) **subassociation *Cirsio erisithalis-Piceetum adenostyletosum alliariae* (Fajmonová 1986) P. Kučera comb. nov. hoc loco** (basionym: *Cortuso-Piceetum adenostyletosum alliariae* Fajmonová 1986 [Fajmonová, 1986, p. 51]; nomenclatural type: Fajmonová (1986), tab. 1, rel. 24, holotypus [Fajmonová, 1986, p. 51]; differential species: *Calamagrostis arundinacea*, *Chrysosplenium alternifolium*, *Cicerbita alpina*, *Clematis alpina*, *Gymnocarpium dryopteris*, *Leucanthemum rotundifolium*, *Poa stiriaca*, *Ranunculus platanifolius*, *Soldanella marmarossiensis* agg.; *Rhizomnium punctatum*, *Rhytidiadelphus triquetrus*; original diagnosis: Fajmonová (1986), tab. 1, rels. 15, 21, 23–25) comprises phytocoenoses developed over slightly deeper calcareous soils, *Adenostyles alliariae* and *Cortusa matthioli* are codominant species.

*Nomenclatural and syntaxonomical note*. – Up to the present, phytocoenoses of this association were included under the association name *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978 (see Fajmonová, 1986). Fajmonová (1978) initially labelled the new association as "*Cortuso-Piceetum* (Sillinger 1933) Šoltés 1976" because it was based on a subassociation cited by Fajmonová (1976) in the form "*Adenostylo-Piceetum cortusetosum* (Sillinger 1933) Šoltés 1976" (cf. Šoltés, 1976).

However, Šoltés (1976) did not describe a "*Cortuso-Piceetum*" as well as Sillinger (1933) did not describe a subassociation "*cortusietosum*". Therefore the both names "*Cortuso-Piceetum* (Sillinger 1933) Šoltés 1976" and

"*Adenostylo-Piceetum cortusetosum* (Sillinger 1933) Šoltés 1976" are here considered as nomina ficta (phantom names) and the following author citations are accepted: *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978 and *Adenostylo-Piceetum cortusetosum* Šoltés 1976.

However, more important are the syntaxonomical differences between the respective original diagnoses of considered units:

(A) Sillinger's (1933) synoptic table of *Piceetum excelsae altherbosum calcicolum* Sillinger 1933 represent for the most part calcareous secondary Norway spruce forests (with *Abies*, *Acer*, *Larix* or *Pinus sylvestris*) of the higher montane altitudes (1250–1380 m a.s.l.) of the Low Tatras (cf. Kučera et al., 2009), only two (? three) of in total ten relevés represent a true *Vaccinio-Piceetea* community; therefore the synoptic table of this Sillinger's unit represent a secondary Norway spruce community of the class *Carpino-Fagetea* (cf. also the new classification of Slovakian *Fagus* communities by Ujházyová et al. (2021));

(B) Šoltés (1976, tab. 1 and tab. 3) published a comparative synoptic table of *Adenostylo-Piceetum cortusetosum* Šoltés 1976 along with 13 original relevés (originally recorded mostly by Lakatosová (1971, tab. 5) [cf. p. 230, 231a]): these original relevés represent for the most part secondary Norway spruce stands developed on habitats of upper montane mixed *Fagus sylvatica* woodland (cf. Kučera, 2012a) and only negligible part of relevés might be identified with natural supramontane Norway spruce stands – and the corresponding original relevé(s) syntaxonomically belong to the association *Adenostylo alliariae-Piceetum* Samek et al. 1957.

(C) Contrary to the previous two units, Fajmonová's (1986) own relevés mostly represent natural supramontane Norway spruce community (and its sub-communities), which are floristically, ecologically and physiognomically different and, consequently, they represent an independent association floristically related to *Seslerio caerulae-Piceetum* Fajmonová 1978 nom. corr.

(D) The nomenclatural evaluation based on the Code's Art. 27d is that association *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978 have to be interpreted following the original differentiation and original diagnosis of the subassociation *Adenostylo alliariae-Piceetum cortusetosum* Šoltés 1976, and not according to Fajmonová's own relevés published by Fajmonová (1986) which represent a syntaxonomically different unit from the one published by Šoltés (1976). For this reason, a new association *Cirsio erisithalis-Piceetum abietis* is here proposed for the three main sub-communities differentiated by Fajmonová (1986) (see Kučera, 2012a).

(E) It migh be argued that the correct author citations should be applied alternatively: "*Adenostylo alliariae-Piceetum cortusetosum* (Sillinger 1933) Šoltés 1976" and, subsequently, "*Cortuso-Piceetum* (Sillinger 1933) Fajmonová 1978". It must be reminded that the resulting plant community had to follow Sillinger's (1933) syntaxonomical content and thus it would belong to the class *Carpino-Fagetea* (see above).

## *Fragario vescae-Piceetum abietis* P. Kučera ass. nov. prov.

Nomenclatural type: Kanka (2008), tab. 19, rel. 3, pro holotypus.

Incl.: *Cortuso-Piceetum calamagrostietosum arundinaceae* Fajmonová 1986 p. p., *Bupleuro longifolii-Laricetum* Kanka 2008 ass. prov. p. p. min. (Art. 3b, 3o)

Set of the most important diagnostic species:

E$_1$: *Actaea spicata*, *Aconitum variegatum*, *Digitalis grandiflora*, *Polypodium vulgare*, *Polystichum aculeatum*, *Geranium robertianum*, **Galium schultesii*, **Tithymalus amygdaloides*, **Calamagrostis arundinacea*.

Relevé data: Fajmonová (1986), tab. 1, rels. 7, 14; Kanka (2008), tab. 17, rels. 2, 10 and tab. 19, rel. 3 and tab. 26, rel. 3; see fig. 2.

Canopy of this community stands is formed by *Picea abies* with admixed *Acer pseudoplatanus*, recorded is also occurrence of *Larix decidua*, *Abies alba* and *Sorbus aucuparia*. Occasional dominance of *Larix decidua* could indicate a specific successional stage or, eventually, result of the former forest management. Understorey species are *Daphne mezereum*, *Ribes petraeum*, *Lonicera nigra* and *Rosa pendulina*.

The constant field layer components are for example the species *Cirsium erisithales*, *Epilobium montanum*, *Fragaria vesca*, *Galium schultesii*, *Gentiana asclepiadea*, *Oxalis acetosella*, *Primula elatior*, *Rubus idaeus*, *Senecio nemorensis* agg. (even with cover-abundance over 5%) and *Valeriana tripteris*; *Calamagrostis arundinacea*, eventually *Dryopteris filix-mas* were here and there observed as distinct dominants. *Cortusa matthioli* and *Mercurialis perennis* are subdominant species in some stands.

Among the other considerably frequent species belong *Aconitum variegatum*, *Adenostyles alliariae* (with low cover), *Astrantia major*, *Pyrethrum clusii*, *Ranunculus lanuginosus* and other species. In contrast to other calcareous Western Carpathian supramontane Norway spruce plant communities, *Vaccinium myrtillus* was not recorded till the present.

Occurrence of species *Campanula persicifolia*, *C. trachelium*, *Digitalis grandiflora* within this natural supramontane *Picea* woodland indicate a nutrient-rich, especially lime-rich and considerably drier habitat. Admixture of soil skeleton is indicated by presence of species *Actaea spicata*, *Asplenium viride*, *Cystopteris fragilis*, *Hylotelephium argutum*, *Mercurialis perennis*, *Polystichum aculeatum*, *P. lonchitis*. Among the low frequent species are also *Anthriscus nitidus*, *Aquilegia vulgaris*, *Calamagrostis varia*, *Carex digitata*, *Delphinium elatum*, *Lilium martagon*, *Salvia glutinosa*.

The most frequently recorded ground layer species is *Eurhynchium angustirete*. Other moss species are infrequent, e.g. *Dicranum scoparium*, *Hylocomium splendens*, *Mnium spinosum*, *Tortella tortuosa*.

*Syntaxonomical note*. – The association *Fragario vescae-Piceetum* ass. prov. integrates species-rich phytocoenoses which are lacking distinct species of the associations *Seslerio caerulae-Piceetum* and *Cirsio erisithalis-Piceetum* (e.g. *Bellidiastrum michelii*, *Pimpinella major*, *Sesleria albicans*) or species bound to one of these units (*Carex sempervirens* ssp. *tatrorum*, *Cystopteris montana*, *Phyteuma orbiculare*, *Ranunculus breyninus* and others). On the other side, they do not have tall-herb character of the stands of the association *Adenostylo alliariae-Piceetum* Samek et al. 1957, even if some of the typical species of the latter unit (for example *Adenostyles alliariae*) could be present; however, with low cover-abundance values only. However, only six relevés of *Fragario vescae-Piceetum* prov. are known up to the present.

Typically developed stands are represented by relevés of Kanka (Kanka, 2008; tab. 19, rel. 3 and tab. 26, rel. 3) from the Belianske Tatry Mts, with *Digitalis grandiflora* accompanied by species *Actaea spicata*, *Campanula persicifolia*, *C. trachelium*, *Geranium robertianum*, *Polystichum aculeatum* and *Polypodium vulgare*.

## *Adenostylo alliariae-Piceetum abietis* Samek et al. 1957 nom. corr. et nom. cons. propos.

Nomenclatural type: Samek et al. (1957), tab. 14, rel. 54, lectotypus hoc loco.

Original name: *Adenostyleto-Piceetum* (Samek et al., 1957, p. 15), i.e. *Adenostyleto alliariae-Piceetum excelsae* Samek et al. 1957 nom. inept. (Art. 30a, 44)

Syntax. syn.: *Adenostylo alliariae-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969 nom. illeg. (Art. 31), *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978

Incl.: *Piceetum excelsae altherbosum calcicolum* Sillinger 1933 subtyp nivový p. p., *Sorbo-Piceetum calcicolum* Šmarda et al. 1971 facies *altherbosum*, *Sorbo-Piceetum calcicolum* Šmarda et al. 1971 facies *oxalidetosum* p. p. min., *Adenostylo alliariae-Piceetum cortusetosum* Šoltés 1976 p. p. min., *Vaccinio myrtilli-Piceetum calamagrostietosum variae* Šoltés 1976 (p. p. min.), *Cortuso-Piceetum calamagrostietosum variae* (Šoltés 1976) Fajmonová 1986

Corresponding nomina ficta (phantom names): *Sorbo-Piceetum calcicolum* Pawłowski 1956 apud Šmarda et al. 1971 p. p., *Cortuso-Piceetum* (Sillinger 1933) Šoltés 1976 apud Fajmonová 1978[11] p. p. min.

Non: *Adenostylo-Piceetum* Hartmann 1953, *Adenostylo alliariae-Piceetum* Zukrigl 1973 nom. illeg. (Art. 31), *Adenostylo alliariae-Piceetum* Ellenberg et Klötzli 1974 nom. illeg. (Art. 31)

Set of the most important diagnostic species:

$E_1$: *Doronicum austriacum*, *Leucanthemum rotundifolium*, *Milium effusum*, *Cicerbita alpina*, **Stellaria nemorum*, **Chaerophyllum hirsutum*,

$E_0$: *Conocephalum conicum*, *Cirriphyllum piliferum.*

Relevé data: Šoltés (1969) (msc.), tab. 8, rels. 36, 38; Šmarda et al. (1971), tab. 18, rel. 6; Šoltés (1976), tab. 3, rels. 2, 7 and tab. 4, rel. 35; Kubíček et al. (1992), tab. 1, rel. 4; Černušáková (1994), tab. 2, rel. 14; Miadok (1995), p. 59, rel. 2 and p. 60, rels. 2, 5, 6; Kubíček et al. (1996), p. 90, rel. 1; Kanka (2008), tab. 16, rels. 3, 6, 8, 9 and tab. 17, rels. 1, 3, 5–9, 14; Krajčí (2009) (msc.), tab. 7, rels. 63, 64; Kučera (2012a), p. 319, rel. 101; see fig. 2.

The dominant tree species of the woodland stands of this community is *Picea abies*, here and there is admixed *Sorbus aucuparia* (ssp. *glabrata*) which could temporarily dominate in early successional stages (after a windthrow) (cf. Šoltés, 1969; Šoltés, 1976). *Larix decidua* was documented only sporadically; however, this tree species was probably more frequent in the regions with its autochthonous occurrence (the Tatra Mountains, some regions of the Low Tatras) before the historical deforestation and other changes of tree species composition. *Acer pseudoplatanus* and in the lower elevations also *Abies alba* were originally components of the canopy layer of the stands.

In the understorey shrub species *Ribes petraeum* and *Daphne mezereum* very frequently grow, less often also *Lonicera nigra*, *Ribes alpinum*, *Rosa pendulina*, sporadically were recorded *Salix silesiaca* and *S. caprea*, and only in the lower limit of natural vertical distribution of this woodland community *Fagus sylvatica*.

Tall-herb character of the field layer is the physiognomically prominent feature of the stands of this community. Most frequently it is formed by dominant *Adenostyles alliariae* with other tall forbs (*Cicerbita alpina*, *Doronicum austriacum*, *Leucanthemum rotundifolium*, *Senecio nemo-*

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[11] According to J.-P. Theurillat (in e-mail), such phantom name should be cited as follows: "*Cortuso-Piceetum* (Sillinger 1933) Šoltés 1976 [recte: *Cortuso-Piceetum* (Šoltés 1976) Fajmonová 1978]".

*rensis* agg.) along with *Luzula sylvatica* ssp. *sylvatica*; occassionally *Dryopteris dilatata* is subdominant species.

Constant species of the lower forb layer are *Oxalis acetosella* (rarely as dominant), *Homogyne alpina*, *Stellaria nemorum*, *Soldanella marmarossiensis* agg., *Ranunculus platanifolius* etc. Characteristic is abundant presence of nutrient-demanding species, for example *Valeriana tripteris*, *Myosotis sylvatica*, *Galeobdolon luteum* agg., *Polygonatum verticillatum*, *Epilobium montanum*, *Primula elatior*, *Phyteuma spicatum*, *Viola biflora*, *Fragaria vesca*, *Thalictrum aquilegiifolium* and others (Kučera, 2012a).

On the contrary to the previous three associations, *Athyrium distentifolium* is here and there component of the stands (along with *A. filix-femina*). Presence of *Vaccinium myrtillus* in the stands is reduced. *Cortusa matthioli* is less frequent, however, here and there it grows with a higher cover (above 5%).

The most frequent ground layer species are *Dicranum scoparium* and *Mnium spinosum*, relatively abundant are also *Plagiothecium curvifolium*, *Conocephalum conicum*, *Cirriphyllum piliferum*, *Hylocomium splendens*. In phytocoenoses with *Sesleria tatrae*, *Ctenidium molluscum* and *Polytrichum formosum* also belong among the more frequent species.

*Variability.* – Following four sub-communities could be distinguished according to the floristical and ecological differences:

(1) **subassociation *Adenostylo-Piceetum typicum*** (nomenclatural type: Samek et al. (1957), tab. 14, rel. 54, holotypus hoc loco, automatical holotype sensu Art. 5b; differential species: *Alchemilla* sp. div., *Chrysosplenium alternifolium*, *Galeobdolon luteum* agg., *Mycelis muralis*, *Paris quadrifolia*, *Ranunculus platanifolius*, *Senecio subalpinus*); original diagnosis: Samek et al. (1957), tab. 14, rels. 32, 54, 45, 25; Šmarda et al. (1971), tab. 18, rel. 6; Šoltés (1976), tab. 3, rels. 2, 7 and tab. 4, rel. 35; Kubíček et al. (1992), tab. 1, rel. 4; Kubíček et al. (1996), p. 90, rel. 1; Kanka (2008), tab. 16, rels. 8, 9 and tab. 17, rels. 3, 14; Krajčí (2009) (msc.), tab. 7, rels. 63, 64; Kučera (2012a), p. 319, rel. 101) represents the most frequent type of the community phytocoenoes.

(2) **subassociation *Adenostylo-Piceetum seslerietosum tatrae* P. Kučera subass. nov. hoc loco** (nomenclatural type: Kanka (2008), tab. 17, rel. 8, holotypus hoc loco; differential species: *Asplenium viride*, *Cirsium erisithales*, *Clematis alpina*, *Huperzia selago*, *Moneses uniflora*, *Sesleria tatrae*; original diagnosis: Kanka (2008), tab. 17, rels. 5–9) unites open canopy woodland from very steep slopes of the Belianske Tatry Mts (cf. Kanka, 2008, tab. 17).

(3) **subassociation *Adenostylo-Piceetum lunarietosum redivivae* P. Kučera subass. nov. hoc loco** (nomenclatural type: Černušáková (1994), tab. 2, rel. 14, holotypus hoc loco; differential species: *Lunaria rediviva*, *Luzula luzuloides*, *Pleurozium schreberi*, *Rhodiola rosea*; original diagnosis: Šoltés 1969 (msc.), tab. 8, rels. 36, 38 [the relevés are published below, with the consent of Dr R. Šoltés], Černušáková (1994), tab. 2, rel. 14) contains phytocoenoses developed on ca. debris habitats (*Lunaria rediviva*), with considerable presence of *Sorbus aucuparia* in the canopy (some relevés represent a successional stage), eventually with *Pinus mugo*.

Šoltés (1969), tab. 8, rel. 36: Belianske Tatry Mts, Rakúsky chrbát, steep slope to the Dolina Siedmich prameňov, 1440 m a.s.l., slope aspect: N, slope inclination: 45°, debris background, plot size 20×20 $m^2$, cover $E_3$: 40%, $E_2$: 30%, $E_1$: 100%, $E_0$: 60%, stand of young rowan trees (25 yrs. old) , R. Šoltés, 12. 8. 1969:

$E_3$: *Sorbus aucuparia* ssp. *glabrata* f. *glabrata* 2, *Salix silesiaca* 1,

$E_2$: *Pinus mugo* 2, *Picea abies* 1, *Salix silesiaca* 1, *Betula carpatica* +

$E_1$: *Lonicera nigra* +, *Picea abies* +, *Ribes uva-crispa* +, *Salix silesiaca* +, *Sorbus aucuparia* [ssp. *glabrata* f. *glabrata* +],

*Avenella flexuosa* 2, *Oxalis acetosella* 2, *Chamerion angustifolium* 2, *Vaccinium myrtillus* 2, *Adenostyles alliariae* 1, *Calamagrostis varia* 1, *Luzula luzuloides* 1, *Soldanella marmarossiensis* agg. 1 [ut *S. montana* ssp. *hungarica*], *Vaccinium vitis-idaea* 1, *Athyrium filix-femina* +, *Campanula tatrae* [ut *C. rotundifolia* ] +, *Doronicum austriacum* +, *Dryopteris carthusiana* +, *D. filix-mas* +, *Fragaria vesca* +, *Galium schultesii* +, *Homogyne alpina* +, *Gentiana asclepiadea* +, *Hieracium murorum* +, *Hypericum maculatum* +, *Moneses uniflora* +, *Myosotis sylvatica* +, *Orthilia secunda* +, *Potentilla aurea* +, *Rubus idaeus* +, *Senecio ovatus* +, *Thymus pulegioides* +, *Cicerbita alpina* r, *Hieracium lachenalii* r, *Leucanthemum rotundifolium* r, *Rhodiola rosea* r, *Valeriana tripteris* r,

$E_0$: *Pleurozium schreberi* 3, *Dicranum scoparium* 2, *Hylocomium splendens* 1, *Rhytidiadelphus triquetrus* 1, *Barbilophozia lycopodioides* +, *Blepharostoma trichophyllum* +, *Eurhynchium* sp. +, *Sanionia uncinata* +, *Plagiothecium curvifolium* +, *Polytrichum formosum* +, *Ptilidium pulcherrimum* +.

Šoltés (1969), tab. 8, rel. 38: Belianske Tatry Mts, under Kozí chrbát, approximately 10 m to the right from the [former] hiking trail towards Skalné vráta, 1420 m a.s.l., slope aspect: NE, slope inclination: 35°, debris background, plot size 20×20 m, cover $E_3$: 75%, $E_2$: 3%, $E_1$: 50%, $E_0$: 5%, stand of old rowan trees (80 yrs. old) with other tree species admixed, R. Šoltés 30. 9. 1969:

$E_3$: *Sorbus aucuparia* ssp. *glabrata* f. *glabrata* 3, *Acer pseudoplatanus* 1, *Larix decidua* 1, *Picea abies* 1,

$E_2$: *Ribes petraeum* 1,

$E_1$: *Daphne mezereum* +, *Ribes petraeum* +, *R. uva-crispa* +, *Lonicera nigra* r,

*Oxalis acetosella* 2, *Asarum europaeum* 1, *Calamagrostis varia* 1, *Cicerbita alpina* 1, *Lunaria rediviva* 1, *Luzula luzuloides* 1, *Myosotis sylvatica* 1, *Athyrium filix-femina* +, *Dryopteris filix-mas* +, *Epilobium montanum* +, *Fragaria vesca* +, *Aegopodium podagraria* +, *Galium schultesii* +, *Gentiana asclepiadea* +, *Hypericum maculatum* +, *Lamium maculatum* +, *Oreogeum montanum* +, *Poa nemoralis* +, *Polygonatum verticillatum* +, *Pulmonaria obscura* +, *Ranunculus lanuginosus* +, *Rhodiola rosea* +, *Rubus idaeus* +, *Senecio ovatus* +, *Stellaria nemorum* +, *Thalictrum aquilegiifolium* +, *Urtica dioica* +,

$E_0$: *Pleurozium schreberi* 1, *Blepharostoma trichophyllum* +, *Dicranum montanum* +, *Plagiothecium curvifolium* +, *Tetraphis pellucida* +.

(4) **subassociation *Adenostylo-Piceetum stellarietosum nemorum* P. Kučera subass. nov. hoc loco** (nomenclatural type: Kanka (2008), tab. 17, rel. 1, holotypus hoc loco; without differential species; original diagnosis: Šoltés (1976), tab. 3, rel. 7; Miadok (1995), p. 59, rel. 2 and p. 60, rels. 2, 5, 6; Kanka (2008), tab. 16, rels. 3, 6 and tab. 17, rel. 1) differentiates by less numerous species composition and absence (or very rare occurrence) of diagnostic species of the previous three sub-communities as well as constant presence of *Stellaria nemorum* (here and there as subdominant species, with cover above 5 or even 25%). According to records available to the present, occurrence of *Petasites albus* is bound to this sub-community, however, only with low frequency and insignificant cover-abundance. This subassociation probably represents a transitional unit towards the association *Mnio spinosi-Piceetum*.

Floristically similar, yet more species-poor phytocoenoses could be developed on non-carbonate habitats: within this subassociation is classified one relevé from glacigenic deposits close to the stream in the glacial valley of Ďumbier Mt. (the western Low Tatras, Miadok (1995), p. 60, rel. 2: presence of *Geranium sylvaticum*, *Primula elatior* or *Aconitum firmum*, *Delphinium oxysepalum*, *Petasites albus*).

*Nomenclatural note*. – (A) The association name was originally described as an alternative name (see Samek et al., 1957, p. 15): "*Piceetum (excelsae) altherbosum. Adenostylo-Piceetum*". According to the current nomenclatural regulations (see Theurillat et al., 2021), such names are accepted as validly published names; the next available later syntaxonomical synonym is *Adenostylo alliariae-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969 nom. illeg. (Art. 31).

(B) *Adenostylo-Piceetum* Samek et al. 1957 is a younger homonym to the name *Adenostylo-Piceetum* Hartmann 1953 (cf. Art. 31). However, Hartmann abandoned his own name and as early as in the year 1959 when he introduced the name *Athyrio alpestris-Piceetum* Hartmann 1959 (validly published later as *Athyrio alpestris-Piceetum* Hartmann ex Hartmann et Jahn 1967).

Though, it remains unnoticed that the name *Adenostylo-Piceetum* Hartmann 1953 has a different syntaxonomical content in comparison to *Athyrio alpestris-Piceetum* Hartmann ex Hartmann et Jahn 1967: while the latter name is considered to represent a natural supramontane *Picea abies* woodland, the former name is based on published relevés of the unit "*Luzulo nemorosae-Piceetum* (Schmid et Gaisberg 1936) Br.-Bl. et Sissingh in Br.-Bl. et al. 1939, *Luzula sylvatica* facies of Bartch & Bartsch (1940)" (cf. Hartmann, 1953, p. XIII of the Anhang) and later classified as *Luzulo luzuloidis-Abietetum luzuletosum sylvaticae* Oberdorfer 1957. Following the original description, this unit represents the montane and originally mixed *Fagus-Abies* woodlands of the class *Carpino-Fagetea* of the Black Forest, due to historical land management commonly with anthropogenically changed tree species composition in favour of conifers (especially *Picea abies*) and as such secondary forest community of the class *Carpino-Fagetea* (cf. Kučera, 2012a).

Therefore contrary to the traditional evaluations (cf. Exner 2007; Willner 2007, p. 240; Chytrý et al. 2013b and other authors), *Adenostylo-Piceetum* Hartmann 1953 and *Athyrio alpestris-Piceetum* Hartmann ex Hartmann et Jahn 1967 are not syntaxonomical synonyms and there is no real need to propose the latter name for conservation above *Adenostylo-Piceetum* Hartmann 1953 (cf. Willner (2007) vs. Kučera & Kliment (2011)).

(C) Willner (2007, p. 238) proposed the name *Adenostylo alliariae-Piceetum* Zukrigl 1973 nom. illeg. (Art. 31) for a nomenclatural conservation against the older unused homonym *Adenostylo-Piceetum* Hartmann 1953 and other three association with the syntaxonomically synonymical names used for Norway spruce forests of the Alps. However, this proposal was based on insufficient literature survey and, subsequently, ignored other older homonyms published for a natural calcareous supramontane Norway spruce woodland of the Western Carpathians (see Samek et al., 1957; Hadač et al., 1969 – published in German language) which have chronological priority above Zukrigl's (1973) name (cf. Kučera & Kliment, 2011; Kučera, 2012a).

Instead, the name *Adenostylo alliariae-Piceetum abietis* Samek et al. 1957 nom. corr. is here proposed for a conserved name (nomen conservandum) to have nomenclatural priority over the unused older homonym and non-synonymous *Adenostylo-Piceetum* Hartmann 1953 established for secondary mixed *Carpino-Fagetea* community (see above) as well as over younger homonym *Adenostylo alliariae-Piceetum* Zukrigl 1973 nom. illeg.

## *Mnio spinosi-Piceetum abietis* Hadač et al. 1969 nom. corr.

Nomenclatural type: Hadač et al. (1969), p. 269, rel. 134, lectotypus (Kučera, 2010a, p. 834).

Original name: *Mnio spinosi-Piceetum* as. nova (Hadač et al. 1969, p. 266), i.e. *Mnio spinosi-Piceetum excelsae* Hadač et al. 1969 nom. inept. (Rec. 10C, Art. 44)

Syntax. syn.: *Oxalido-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969, *Polysticho lonchitidis-Piceetum* W. Matuszkiewicz ex J. Matuszkiewicz 1977

Incl.: *Piceetum excelsae normale* Szafer et al. 1927 nom. illeg. p. p. min. (Art. 13a), *Sorbo-Piceetum calcicolum* Šmarda et al. 1971 facies *oxalidetosum* p. p. maj.

Pseud: *Piceetum normale* sensu Szafer et al. 1923 non Beger 1922 p. p. min. (cf. also Principle II)

Nomen fictum (phantom name): *Sorbo-Piceetum calcicolum* Pawłowski 1956 apud Šmarda et al. 1971

Non: *Piceetum excelsae normale* Sillinger 1933 nom. inval. (Art. 3d), *Piceetum excelsae normale calcicolum* Sillinger 1933 nom. illeg. (Art. 34a), *Piceetum excelsae normale silicicolum* Sillinger 1933 nom. illeg. (Art. 34a), *Piceetum abietis oxalidetosum acetosellae silicicolum* Krajina 1933 nom. inval. (Art. 3e), *Oxalido-Piceetum* auct. bohem. non Březina et Hadač in Hadač et al. 1969

Set of the most important diagnostic species: negative species differentiation.

Relevé data: Hadač et al. (1969), p. 269, rels. 131, 139; Šmarda et al. (1971), tab. 18, rels. 8, 14; Kobzáková 1987 (msc.), tab. 8, rel. 7; Černušáková (1994), tab. 1, rels. 4, 5 and tab. 2, rels. 1–3, 15; Kanka (2008), tab. 14, rels. 6, 7; see fig. 3.

*Picea abies* stands with admixture of *Sorbus aucuparia* (ssp. *glabrata*), on places with the high canopy cover without the latter species. *Acer pseudoplatanus* was originally admixed in the tree layer, *Larix decidua* was eventually present in regions with its autochthonous distribution, in the lower altitudes *Abies alba.* Among the more frequent shrub species belong only *Ribes petraeum*.

This community considerably differs from the previous communities with its usually low-forb field layer character and with low number of present species (somewhere even less than 15–20 species) which commonly reach only low cover values (up to 5%). The number of constant species is also considerably lower. Frequent relatively low total cover of the field layer corresponds to the mentioned features (not seldom up to 50% at most, here and there only 1–3%, cf. Hadač et al. (1969), 269, 274).

The constant components of the stands are only *Oxalis acetosella*, *Soldanella* spp. (more frequently *S. carpatica* was noted), *Senecio nemorensis* agg., *Vaccinium myrtillus*, *Mycelis muralis*, *Myosotis sylvatica* and *Prenanthes purpurea*. In some stands among the more frequent species belong *Adenostyles alliariae* (usually with very low cover-abundance), *Valeriana tripteris*, *Homogyne alpina*, *Galeobdolon luteum* agg., or *Moneses uniflora*, *Corallorhiza trifida*, *Primula elatior* or *Phyteuma spicatum*, *Ranunculus platanifolius*; on some habitats also *Polystichum lonchitis*, *Lycopodium annotinum*, *Vaccinium vitis-idaea*, *Viola biflora* (cf. Adamczyk, 1962).

The field layer does not have a dominant species or, alternatively, *Oxalis acetosella* could reach cover over 50 % in some places; eventually *Adenostyles alliariae* or *Athyrium* spp. also grow abundantly.

The ground layer does not have a specific constant species according to the currently known records. In some stands the dominant moss species are *Dicranum scoparium* and *Plagiomnium cuspidatum*, constantly accompanied by *Hylocomium splendens* and *Brachythecium velutinum* (Hadač et al., 1969, p. 274–275). Occurrence of *Sphagnum girgensohnii* was sporadically noted.

*Variability.* – With respect to the low total number of recorded phytocoenological relevés (i.e. with addition of originally unclassified relevés of Hadač et al. (1969), see Methods above), the three following subcommunities are differentiated:

(1) **subassociation *Mnio spinosi-Piceetum typicum* subass. nov. hoc loco** (nomenclatural type: Hadač et al. (1969), p. 269, rel. 134, holotypus hoc loco, automatical holotype sensu Art. 5b; differential species: *Corallorhiza trifida*, *Hieracium murorum*, *Moneses uniflora*, *Primula elatior*, *Solidago virgaurea*; original diagnosis: Hadač et al. (1969), p. 269, rels. 131, 134, 139 and p. 274, rels. 30, 32, 34, 55; Šmarda et al. (1971), tab. 18, rels. 8, 14; Kanka (2008), tab. 14, rels. 6, 7) which splits into two variants: (a) ***Valeriana tripteris*-variant** (incl. *Oxalido-Piceetum* Hadač et al. 1969 s. str.) (differential species: *Athyrium filix-femina*, *Cicerbita alpina*, *Homogyne alpina*, *Luzula sylvatica*, *Polygonatum verticillatum*, *Valeriana tripteris*; *Brachythecium velutinum*, *Dicranum scoparium*, *Plagiomnium cuspidatum*) with characteristic distinctive dominace of *Oxalis acetosella*, and (b) ***Mycelis muralis*-variant** (≡ *Mnio spinosi-Piceetum* Hadač et al. 1969 sensu strictissimo) (without differential species) which includes woodland stands with usually very the low cover of the field layer (1–3%).

(2) **subassociation *Mnio spinosi-Piceetum phyteumatetosum spicati* P. Kučera subass. nov. hoc loco** (nomenclatural type: Černušáková (1994), tab. 2, rel. 15, holotypus hoc loco; differential species: *Athyrium distentifolium*, *Gentiana asclepiadea*, *Phyteuma spicatum*, *Ranunculus platanifolius*, *Veratrum album* ssp. *lobelianum*; original diagnosis: Černušáková (1994), tab. 1, rel. 4 and tab. 2, rels. 1–3, 15) contains physiognomically different more or less tall-forb stands. ***Adenostyles alliariae*-variant** (differential species: *Adenostyles alliariae*, *Athyrium distentifolium*, *Luzula sylvatica*, *Myosotis sylvatica*, *Phyteuma spicatum*, *Ranunculus platanifolius*) is characterized by dominance of *Adenostyles alliariae* (cover up to 25–50%). In the ***Ribes petraeum*-variant** (differential species: cf. *Athyrium filix-femina*, *Ribes petraeum*) species *Athyrium filix-femina* dominates and differential species of the former variant are absent.

(3) **subassociation *Mnio spinosi-Piceetum melampyretosum sylvatici* P. Kučera subass. prov.** (nomenclatural type: Černušáková (1994), tab. 1, rel. 5, pro holotypus; differential species: *Galium schultesii*, *Melampyrum sylvaticum*; original diagnosis: Kobzáková (1987) (msc.), tab. 8, rel. 7; Černušáková (1994), tab. 1, rel. 5;) differs from the previous two sub-communities by absence of their differential species (*Athyrium distentifolium* could be present). However, this unit includes only two known relevés, including one relevé of Kobzáková (1987) from the non-carbonate region of the Západné Tatry Mts. (with presence of species *Astrantia major*, *Galeobdolon lutem* agg., *Galium schultesii*, *Rubus saxatilis*, *Aruncus vulgaris*, *Ranunculus lanuginosus*).[12]

*Nomenclature.* – Březina and Hadač (in Hadač et al. (1969)) validly published two new names of the syntaxonomically very close communities (cf. Kučera, 2012a): (1) *Mnio spinosi-Piceetum* proposed as a new association and (2) *Oxalido-Piceetum* originally proposed as nomen novum for the name *Piceetum abietis oxalidetosum acetosellae silicicolum* Krajina 1933. However, the latter name was invalidly published (see Kučera in red.) therefore the correct author citation for the respective *Oxalido-Piceetum* community of the Belianske Tatry Mts (Hadač et al., 1969) is *Oxalido-Piceetum excelsae* Březina et Hadač in Hadač et al. 1969.

These two communities are merged to one association due to their floristical and ecological similarity (see Kučera, 2012a). In respect of potential nomenclatural and also syntaxonomical problems with the name *Oxalido-Piceetum* (Kučera, in red.), the respective association is labelled with the unequivocal name *Mnio spinosi-Piceetum* Hadač et al. 1969.

## *Hieracio murorum-Piceetum abietis* P. Kučera ass. nov. hoc loco

Nomenclatural type: Kučera (2012a), p. 288, rel. 5, lectotypus hoc loco.

Set of the most important diagnostic species:

$E_1$: *Agrostis capillaris*, *Calamagrostis villosa*, *Luzula luzuloides*, **Stellaria nemorum*, *Deschampsia cespitosa*, **Calamagrostis arundinacea*,

$E_0$: *Polytrichum formosum*, *Pellia endiviifolia*.

Relevé data and original diagnosis (see Table 3): Kučera (2002) (msc.), tab. 5, rels. 4–6; Kučera (2012a), p. 288, rel. 5 and p. 289, rels. 9–10; see fig. 2.

Canopy of the currently known stands is formed only by *Picea abies.* However, native tree species were originally also *Acer pseudoplatanus*, *Sorbus aucuparia*, in the lower altitudes *Abies alba*, and eventually sporadic *Fagus sylvatica* with low growth.

Field layer of the hitherto known phytocoenoses is dominated by *Calamagrostis villosa*. Very abundant are also *Stellaria nemorum* and *Vaccinium myrtillus*. Higher covers are here and there reached by *Athyrium filix-femina*, *Luzula sylvatica* ssp. *sylvatica* or *Senecio hercynicus*. Frequent components of the stands are *Adenostyles alliariae*, *Calamagrostis arundinacea*, *Dryopteris dilatata*, *D. expansa*.

Presence of calcicoles and nutrient-demanding species is reduced, however, this association unequivocally belong to the group of calcicolous natural Norway spruce communities which is justified by presence patterns of the species *D. filix-mas*, *Hieracium murorum*, *Myosotis sylvatica*, *Stellaria nemorum* and occasional occurrence of species as *Alchemilla* sp. div., *Geranium sylvaticum*, *Primula elatior* and so on (see Kučera in prep., tab. 2).

A characteristic feature of the hitherto known stands is the presence of species *Agrostis capillaris*, *Alchemilla* sp. div., *Anthoxanthum odoratum*, *Deschampsia cespitosa*, *Hypericum maculatum*, *Phleum rhaeticum*, *Potentilla aurea* etc., which indicate impact of the historical land management (high mountain grazing and deforestation).

In contrast to the previous calcicolous communities, the ground layer is regularly developed with higher cover. In the ground layer *Polytrichum formosum* usually dominates, sporadically also *P. commune*, both species could reach cover above 5%. Frequently are growing species *Dicranum scoparium* and *Plagiothecium curvifolium*, less frequently calcicole *Pellia endiviifolia*.

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[12] In respect of the relevé species composition, the original misidentification of the locality might be possible.

**Table 3:** Original diagnosis of the association *Hieracio murorum-Piceetum abietis* P. Kučera 2022 ass. nov.
**Tabela 3:** Originalni opis asociacije *Hieracio murorum-Piceetum abietis* P. Kučera 2022 ass. nov.

| Rel. No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **Tree and shrub species** | | | | | | |
| **$E_3$** | | | | | | |
| *Picea abies* | 4 | 5 | 4 | 4 | 3 | 4 |
| **$E_1$** | | | | | | |
| *Picea abies* | + | + | + | . | + | + |
| *Sorbus aucuparia* | r | r | + | + | . | + |
| *Acer pseudoplatanus* | + | + | + | . | . | + |
| *Fagus sylvatica* | r | r | . | . | r | . |
| *Salix silesiaca* | . | . | . | r | . | . |
| **Field layer species** | | | | | | |
| *Calamagrostis villosa* | 4 | 1 | 1 | 3 | 5 | 2 |
| *Vaccinium myrtillus* | 2 | 2 | 2 | 3 | 1 | 2 |
| *Stellaria nemorum* | 2 | 2 | 2 | 2 | 2 | 2 |
| *Dryopteris carthusiana* agg. | 2 | 1 | + | 2 | 2 | 2 |
| *Luzula sylvatica* ssp. *sylvatica* | 2 | + | + | 1 | 1 | 1 |
| *Oxalis acetosella* | 1 | + | 1 | + | + | + |
| *Luzula luzuloides* | 1 | + | + | 1 | 1 | 2 |
| *Homogyne alpina* | + | + | + | 1 | 1 | 2 |
| *Rubus idaeus* | + | r | + | 1 | + | + |
| *Senecio nemorensis* agg. | 2 | 1 | + | . | 1 | + |
| *Athyrium filix-femina* | 2 | 1 | + | . | 2 | + |
| *Adenostyles alliariae* | 1 | r | + | . | 1 | 1 |
| *Calamagrostis arundinacea* | + | + | . | 1 | 1 | 2 |
| *Agrostis capillaris* | + | + | . | + | + | + |
| *Hieracium murorum* | r | . | + | + | + | + |
| *Dryopteris filix-mas* | + | r | + | 2 | . | . |
| *Myosotis sylvatica* | + | . | . | + | . | + |
| *Athyrium distentifolium* | 1 | . | . | . | + | + |
| *Soldanella carpatica* | + | + | + | . | . | . |
| *Avenella flexuosa* | + | + | . | + | . | . |
| *Deschampsia cespitosa* | + | . | . | 1 | . | + |
| *Rumex alpestris* | + | . | . | r | . | + |
| *Alchemilla* sp. div. | . | . | . | + | + | + |
| *Ranunculus repens* | 1 | . | . | + | . | . |
| *Anthoxanthum odoratum* | + | + | . | . | . | . |
| *Viola biflora* | + | . | + | . | . | . |
| *Phegopteris connectilis* | + | . | . | . | + | . |
| *Prenanthes purpurea* | r | . | . | . | . | r |
| *Poa annua* | . | + | + | . | . | . |
| *Veronica chamaedrys* | . | . | . | r | . | + |
| *Campanula serrata* | . | . | . | . | + | + |
| *Hypericum maculatum* | . | . | . | . | + | + |
| **Ground layer species** | | | | | | |
| *Polytrichum formosum* | 1 | 2 | 2 | 2 | . | 2 |
| *Plagiothecium curvifolium* | 1 | + | + | . | . | + |
| *Dicranum scoparium* | + | + | 1 | . | . | 1 |
| *Pellia endiviifolia* | . | 1 | + | . | . | . |
| *Pellia* sp. | . | . | . | . | . | + |
| *Polytrichum commune* | 2 | 2 | . | . | . | . |

**Field and ground layer species present in one relevé only:**

Rel. 1: $E_1$: *Epilobium montanum* +, *Galium odoratum* +, *Primula elatior* +; – $E_0$: *Brachythecium starkei* +.
Rel. 2: $E_1$: *Gnaphalium* sp. r, *Potentilla aurea* r; – $E_0$: *Atrichum undulatum* 2.
Rel. 3: $E_1$: *Chrysosplenium alternifolium* +, *Maianthemum bifolium* +, *Phleum rhaeticum* +, *Allium victorialis* r, *Veratrum album* ssp. *lobelianum* r; – $E_0$: *Calypogeia azurea* +, *Dicranella heteromalla* +.
Rel. 4: $E_1$: *Tussilago farfara* 1, *Galeopsis speciosa* +, *Nardus stricta* +, *Urtica dioica* +.
Rel. 5: $E_1$: *Senecio subalpinus* +.
Rel. 6: $E_1$: *Festuca* sp. 1, *Chaerophyllum hirsutum* +, *Geranium sylvaticum* +, *Phleum pratense* +, *Polygonatum verticillatum* +; – $E_0$: *Plagiomnium rostratum* +.

**Localities:**

Rel. 1: Kučera 2012a, p. 289, rel. 9 – Veľká Fatra Mts, Borišov Mt., right part of the Prvý Balov, near the ridge, 1407 m a.s.l., 19. 8. 2008, P. Kučera (PK173).
Rel. 2: Kučera 2012a, p. 289, rel. 10 – Veľká Fatra Mts, Borišov Mt., right part of the Prvý Balov, next to the forest line near a dell/avalanche track, 1427 m a.s.l., 26. 7. 2006, P. Kučera (PK113).
Rel. 3: Kučera 2012a, p. 288, rel. 5 – Veľká Fatra Mts, Borišov Mt., on the ridge between the Prvý Balov and Druhý Balov, 1447 m a.s.l., 23. 7. 2003, P. Kučera (PK63).
Rel. 4: Kučera 2002 (msc.), tab. 5, rel. 5 – Veľká Fatra Mts, Borišov Mt., right part of the Prvý Balov, ca. 1400 m a.s.l., 25. 8. 2001, P. Kučera (PK48); originally classified as "*Athyrio alpestris-Piceetum* Hartmann 1959".
Rel. 5: Kučera 2002 (msc.), tab. 5, rel. 6 – Veľká Fatra Mts, Borišov Mt., right part of the Prvý Balov, ca. 1405 m a.s.l., 25. 8. 2001, P. Kučera (PK49); originally classified as "*Athyrio alpestris-Piceetum* Hartmann 1959".
Rel. 6: Kučera 2002 (msc.), tab. 5, rel. 4 – Veľká Fatra Mts, Borišov Mt., right part of the Prvý Balov, ca. 1450 m a.s.l., 25. 8. 2001, P. Kučera (PK45); originally classified as "*Athyrio alpestris-Piceetum* Hartmann 1959".

To the present, phytocoenoses of the association *Hieracio murorum-Piceetum* were recorded only in the Veľká Fatra Mts., in the northern slopes of Borišov Mt., where they are protected within the Borišov National Nature Reserve. Originally the respective woodland stands were widely distributed on the whole main ridge of the Veľká Fatra Mts, and most probably also elsewhere within the Western Carpathians, e.g. the Malá Fatra Mts. (Stoh Mt.), the eastern Low Tatras (Veľký Bok Mt.).

In all the mentioned areas, the geological background is formed by less resistant calcareous rocks of the Mráznica formation, i.e. grey marly limestones, marlstones and marly shales (Polák et al., 1997) and, consequently, the relief of the slopes is smooth-faced, without rugged ridges, rocky ribs and rock cuts and only exceptionally with bouldery taluses. This terrain characteristic was used for extensive (pre-)historical deforestation, altitudinally from the ridges deeply to the horizon of the mixed montane *Fagus* woodland, therefore the original supramontane Norway spruce stands are usually not preserved. The recorded old stands of the Borišov Mt. are also influenced by historical (partly present) mountain grazing (see above).

In places where the natural habitat development would conclude with blocking the influence of the carbonate background, phytocoenoses of the alliance *Piceion abietis* Pawłowski ex Pawłowski et al. 1928 nom. corr. could develop and replace the *Hieracio murorum-Piceetum* woodland. Such stands did not preserve due to the mentioned large-scale deforestation.

## Higher syntaxonomical units of calcareous Norway spruce woodlands

The above-presented Western Carpathian and other similar European syntaxa of *Picea abies* communities are traditionally classified within the order *Athyrio-Piceetalia* Hadač 1962 or, recently, under the order name "*Athyrio filicis-feminae-Piceetalia* Hadač ex Hadač et al. 1969" (Kučera, 2010a; Mucina et al., 2016 and other following authors). The latter name was proposed to be the first validly published counterpart of the supposedly invalid name *Athyrio-Piceetalia* Hadač 1962. However, the corresponding nomenclatural construction was incorrect because two of the totally three subordinated alliances were in fact validly published by Hadač (1962) (cf. Kučera, in red.).

Thorough revision of the original diagnoses of the alliances *Oxalido-Piceion* (Krajina 1933) Březina et Hadač in Hadač 1962 and *Chrysanthemo-Piceion* (Krajina 1933) Březina et Hadač in Hadač 1962, i.e. *Oxalidion acetosellae* Krajina 1933 and *Chrysanthemion rotundifolii* Krajina 1933, demonstrated that later application of the respective alliances is syntaxonomically incompatible with their original phytocoenotical delimitation. The factual utilization of these alliance names as pseudonyma, i.e. "*Oxalido-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962" and "*Chrysanthemo-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962" has begun in the vegetation surveys of Holub et al. (1967) and Hadač et al. (1969) and continues to the present (Kučera, in red.).

As the syntaxonomical delimitation of the order *Athyrio-Piceetalia* Hadač 1962 is defined by its original diagnosis, i.e. alliances *Oxalido-Piceion* (Krajina 1933) Březina et Hadač in Hadač 1962 and *Chrysanthemo-Piceion* (Krajina 1933) Březina et Hadač in Hadač 1962, the common application of this order name equally corresponds to the pseudonym *Athyrio-Piceetalia* auct. non Hadač 1962 (Kučera, in red.). The pseudonymical approach to the name was already expressed in Hadač's (1962, p. 53) own short ecological and floristical characteristics of the order and constantly continues to the present (cf. Mucina et al., 2016; Dubyna et al., 2019; Bergmeier, 2020). The here presented name *Cortuso-Piceetalia* is published to replace the pseudonym *Athyrio-Piceetalia* auct. non Hadač 1962.

## *Cortuso matthioli-Piceetalia abietis* P. Kučera ord. nov. hoc loco

Nomenclatural type: alliance *Cortuso matthioli-Piceion abietis* P. Kučera 2022 (see below p. 141), holotypus hoc loco

Pseudonym: *Athyrio-Piceetalia* auct. non Hadač 1962

Original diagnosis: *Cortuso matthioli-Piceion abietis* P. Kučera 2022 [see below p. 141], *Melico nutantis-Piceion* (Kielland-Lund 1981) P. Kučera 2022 [see below p. 139], *Calamagrostio variae-Pinion cembrae* P. Kučera 2017 [Kučera, 2017, p. 414], *Seslerio caeruleae-Pinion uncinatae* Vigo 1974 [Vigo, 1974, p. 53]

Differential species (see Table 4):[13]

$E_2$: (*Ribes petraeum*);

$E_1$: *Daphne mezereum*, *Ribes petraeum*, *Acer pseudoplatanus*, (*Lonicera nigra*);

*Valeriana tripteris*, *Primula elatior*, *Phyteuma spicatum*, *Cortusa matthioli*, *Polygonatum verticillatum*, *Hieracium murorum*, *Viola biflora*, *Myosotis sylvatica*, *Geranium sylvaticum*, *Calamagrostis varia*, *Asplenium viride*, *Astrantia major*, *Cirsium erisithales*, *Cicerbita alpina*, *Leucanthemum rotundifolium*, *Galeobdolon luteum* agg., *Heracleum sphondylium*, *Polystichum lonchitis*, *Crepis paludosa*, *Mycelis*

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[13] Species with the fidelity value (φ × 100) lower that "33" are in brackets.

**Table 4:** Differential table of the supramontane Norway spruce woodlands of the class *Vacccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 in Slovakia with values of constancy (%) and fidelity (φ × 100) in the exponent.

**Table 4:** Diferencialna tabela supramontanskih smrekovih gozdov razreda *Vacccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 na Slovaškem s prikazano stalnostjo (%) in nadpisano navezanostjo (φ × 100).

The relevé dataset is identical with the Tabble 2 (synoptic table of the order *Cortuso matthioli-Piceetalia*) and the Table 3 (synoptic table of the order *Piceetalia abietis*) compiled by Kučera (in prep.).

Species with fidelity value (φ × 100) lower than 25 are omitted.

Group 1 – *Cortuso matthioli-Piceetalia abietis* P. Kučera 2022 ord. nov.
Group 2 – *Piceetalia abietis* Pawłowski ex Pawłowski et al. 1928 nom. corr.

| Group No. | 1 | 2 |
|---|---|---|
| No. of relevés | 95 | 185 |
| **Tree and shrub species** | | |
| **E$_2$** | | |
| *Ribes petraeum* | 16 $^{26.5}$ | 1 $^{-}$ |
| **E$_1$** | | |
| *Daphne mezereum* | 47 $^{\mathbf{55.7}}$ | . $^{-}$ |
| *Ribes petraeum* | 31 $^{36.4}$ | 3 $^{-}$ |
| *Acer pseudoplatanus* | 20 $^{33.3}$ | . $^{-}$ |
| *Lonicera nigra* | 37 $^{31.3}$ | 10 $^{-}$ |
| **Field layer species (E$_1$)** | | |
| *Valeriana tripteris* | **74** $^{\mathbf{73.7}}$ | 2 $^{-}$ |
| *Primula elatior* | **56** $^{\mathbf{62.2}}$ | . $^{-}$ |
| *Phyteuma spicatum* | **55** $^{\mathbf{60.6}}$ | 1 $^{-}$ |
| *Cortusa matthioli* | **52** $^{\mathbf{59.0}}$ | . $^{-}$ |
| *Polygonatum verticillatum* | **60** $^{\mathbf{57.5}}$ | 6 $^{-}$ |
| *Hieracium murorum* | **61** $^{\mathbf{56.3}}$ | 8 $^{-}$ |
| *Viola biflora* | 47 $^{\mathbf{55.7}}$ | . $^{-}$ |
| *Myosotis sylvatica* | 47 $^{\mathbf{55.7}}$ | . $^{-}$ |
| *Geranium sylvaticum* | 43 $^{\mathbf{51.6}}$ | 1 $^{-}$ |
| *Calamagrostis varia* | 41 $^{\mathbf{50.8}}$ | . $^{-}$ |
| *Asplenium viride* | 41 $^{\mathbf{50.8}}$ | . $^{-}$ |
| *Astrantia major* | 39 $^{49.2}$ | . $^{-}$ |
| *Cirsium erisithales* | 39 $^{49.2}$ | . $^{-}$ |
| *Cicerbita alpina* | 38 $^{48.3}$ | . $^{-}$ |
| *Leucanthemum rotundifolium* | 39 $^{48.2}$ | 1 $^{-}$ |
| *Galeobdolon luteum* agg. | 40 $^{47.3}$ | 2 $^{-}$ |
| *Heracleum sphondylium* | 36 $^{46.7}$ | . $^{-}$ |
| *Polystichum lonchitis* | 36 $^{46.7}$ | . $^{-}$ |
| *Crepis paludosa* | 35 $^{45.8}$ | . $^{-}$ |
| *Mycelis muralis* | 36 $^{44.8}$ | 1 $^{-}$ |
| *Fragaria vesca* | 32 $^{43.3}$ | . $^{-}$ |
| *Clematis alpina* | 31 $^{42.4}$ | . $^{-}$ |
| *Galium schultesii* | 32 $^{42.3}$ | 1 $^{-}$ |
| *Dryopteris filix-mas* | 38 $^{42.0}$ | 4 $^{-}$ |
| *Ranunculus platanifolius* | 37 $^{41.1}$ | 4 $^{-}$ |
| *Soldanella marmarossiensis* agg. | 49 $^{40.7}$ | 12 $^{-}$ |
| *Chaerophyllum hirsutum* | 32 $^{40.3}$ | 2 $^{-}$ |
| *Epilobium montanum* | 32 $^{39.3}$ | 2 $^{-}$ |
| *Bellidiastrum michelii* | 26 $^{38.9}$ | . $^{-}$ |
| *Mercurialis perennis* | 26 $^{38.9}$ | . $^{-}$ |
| *Soldanella carpatica* | 28 $^{38.5}$ | 1 $^{-}$ |
| *Cardaminopsis arenosa* agg. | 25 $^{38.0}$ | . $^{-}$ |
| *Sesleria caerulea* | 25 $^{38.0}$ | . $^{-}$ |
| *Thalictrum aquilegiifolium* | 22 $^{35.3}$ | . $^{-}$ |
| *Pyrethrum clusii* | 22 $^{35.3}$ | . $^{-}$ |
| *Senecio subalpinus* | 22 $^{35.3}$ | . $^{-}$ |
| *Maianthemum bifolium* | 26 $^{34.6}$ | 2 $^{-}$ |
| *Senecio nemorensis* agg. | 72 $^{34.4}$ | 37 $^{-}$ |
| *Chrysosplenium alternifolium* | 20 $^{33.3}$ | . $^{-}$ |
| *Cystopteris fragilis* | 20 $^{33.3}$ | . $^{-}$ |
| *Campanula rotundifolia* agg. | 22 $^{31.7}$ | 2 $^{-}$ |
| *Cystopteris montana* | 18 $^{31.3}$ | . $^{-}$ |
| *Pimpinella major* | 18 $^{31.3}$ | . $^{-}$ |
| *Adenostyles alliariae* | **72** $^{31.3}$ | 41 $^{-}$ |
| *Lilium martagon* | 19 $^{31.0}$ | 1 $^{-}$ |
| *Alchemilla* sp. div. | 19 $^{31.0}$ | 1 $^{-}$ |
| *Moneses uniflora* | 20 $^{30.8}$ | 1 $^{-}$ |
| *Ranunculus lanuginosus* | 17 $^{30.3}$ | . $^{-}$ |
| *Geum rivale* | 17 $^{30.3}$ | . $^{-}$ |
| *Aconitum variegatum* | 17 $^{30.3}$ | . $^{-}$ |
| *Dentaria enneaphyllos* | 17 $^{30.3}$ | . $^{-}$ |
| *Rubus saxatilis* | 18 $^{30.0}$ | 1 $^{-}$ |
| *Veratrum allbum* ssp. *lobelianum* | 46 $^{29.9}$ | 18 $^{-}$ |
| *Prenanthes purpurea* | **57** $^{28.5}$ | 29 $^{-}$ |
| *Carex digitata* | 15 $^{28.2}$ | . $^{-}$ |
| *Carduus glaucinus* | 14 $^{27.1}$ | . $^{-}$ |
| *Phyteuma orbiculare* | 14 $^{27.1}$ | . $^{-}$ |
| *Ranunculus breyninus* | 13 $^{26.0}$ | . $^{-}$ |
| *Crepis jacquinii* | 13 $^{26.0}$ | . $^{-}$ |
| *Sesleria tatrae* | 13 $^{26.0}$ | . $^{-}$ |
| *Carex sempervirens* ssp. *tatrorum* | 13 $^{26.0}$ | . $^{-}$ |
| *Calamagrostis villosa* | 25 $^{-}$ | **75** $^{49.9}$ |
| *Avenella flexuosa* | **51** $^{-}$ | **89** $^{42.1}$ |
| *Dryopteris carthusiana* agg. | **54** $^{-}$ | **90** $^{40.0}$ |
| *Vaccinium myrtillus* | 77 $^{-}$ | **99** $^{33.8}$ |
| *Lycopodium annotinum* | 3 $^{-}$ | 19 $^{25.7}$ |
| **Ground layer species (E$_0$)** | | |
| *Mnium spinosum* | 38 $^{47.4}$ | 1 $^{-}$ |
| *Ctenidium molluscum* | 23 $^{36.2}$ | . $^{-}$ |
| *Tortella tortuosa* | 24 $^{32.6}$ | 2 $^{-}$ |
| *Polytrichum formosum* | 19 $^{-}$ | **71** $^{\mathbf{52.7}}$ |
| *Calypogeia integristipula* | . $^{-}$ | 23 $^{36.3}$ |
| *Dicranum scoparium* | **53** $^{-}$ | **86** $^{36.1}$ |
| *Sphagnum girgensohnii* | 4 $^{-}$ | 22 $^{26.5}$ |

*muralis*, *Fragaria vesca*, *Clematis alpina*, *Galium schultesii*, *Dryopteris filix-mas*, *Ranunculus platanifolius*, *Soldanella marmarossiensis* agg., *Chaerophyllum hirsutum*, *Epilobium montanum*, *Bellidiastrum michelii*, *Mercurialis perennis*, *Soldanella carpatica*, *Cardaminopsis arenosa* agg., *Sesleria albicans*, *Thalictrum aquilegiifolium*, *Pyrethrum clusii*, *Senecio subalpinus*, *Maianthemum bifolium*, *Senecio nemorensis* agg., *Chrysosplenium alternifolium*, *Cystopteris fragilis*, (*Campanula rotundifolia* agg., *Cystopteris montana*, *Pimpinella major*, *Adenostyles alliariae*, *Lilium martagon*, *Alchemilla* sp. div., *Moneses uniflora*, *Ranunculus lanuginosus*, *Geum rivale*, *Aconitum variegatum*, *Dentaria enneaphyllos*, *Rubus saxatilis*, *Veratrum allbum* ssp. *lobelianum*, *Prenanthes purpurea*, *Carex digitata*, *Carduus glaucinus*, *Phyteuma orbiculare*, *Ranunculus breyninus*, *Crepis jacquinii*, *Sesleria tatrae*, *Carex sempervirens* ssp. *tatrorum*);

$E_0$: *Mnium spinosum*, *Ctenidium molluscum*, (*Tortella tortuosa*).

*Floristical delimitation.* – The characteristic feature of communities of the order *Cortuso matthioli-Piceetalia* within the class *Vaccinio-Piceetea* is the presence of species which are – within the altitudinal vegetation zone of natural *Picea abies* woodland and natural (mixed) *Pinus cembra* woodland, i.e. in the supramontane vegetation zone – (almost exclusively) bounded to calcareous soils: *Astrantia major*, *Chrysosplenium alternifolium*, *Crepis paludosa*, *Dentaria enneaphyllos*, *Fragaria vesca*, *Galium schultesii*, *Geranium sylvaticum*, *Heracleum sphondylium*, *Mercurialis perennis*, *Moneses uniflora*, *Mycelis muralis*, *Myosotis sylvatica*, *Phyteuma spicatum*, *Polystichum lonchitis*, *Primula elatior*, *Valeriana tripteris*, *Viola biflora* and others (see above). Only sporadically and on special habitats some species of this group could occur in the communities of the order *Piceetalia abietis* Pawłowski ex Pawłowski et al. 1928 (see Kučera, 2019a, tab. 1).

Within the class *Vaccinio-Piceetea*, the fundamental differential element of the *Cortuso matthioli-Piceetalia* communities of the high mountain elevations is the presence of calciphytes, for example *Asplenium viride*, *Calamagrostis varia*, *Carduus glaucinus*, *Cirsium erisithales*, *Cortusa matthioli*, *Cystopteris montana*, *Phyteuma orbiculare*, *Pimpinella major* or *Sesleria albicans*. These species not seldom constitute a significant share of the species composition of phytocoenoses or of their total cover (cf. Hadač et al., 1969; Fajmonová, 1978; Fajmonová, 1986; Kučera, 2012a). Reduced presence of calciphytes is limited to marginal communities of the order (e.g. *Hieracio murorum-Piceetum* P. Kučera 2022).

The ground layer of the *Cortuso matthioli-Piceetalia* communities is distinguished by presence of mosses *Ctenidium molluscum*, *Mnium spinosum* and *Tortella tortuosa*.

In contrast to generally accepted assessments that the class *Vaccinio-Piceetea* represents species-poor and acid woodland vegetation (e.g. Seibert, 1992; Chytrý in Chytrý et al., 2013), the respective calcareous natural Norway spruce woodlands constitute the proof that the *Vaccinio-Piceetea* communities comprise species-rich and very species-rich phytocoenoses as well. The concept of *Vaccinio-Piceetea* diagnostic taxa should also be revised: instead of species growing within large diversity of forest and non-forest vegetation (such as *Vaccinium myrtillus*, *V. vitis-idaea*), species common for both *Piceetalia abietis* and *Cortuso-Piceetalia abietis* syntaxa should be emphasized, i.e. (Central) European oreal species as *Adenostyles alliariae*, *Homogyne alpina* or *Luzula sylvatica* (cf. Kučera, in prep.).

*Ecological delimitation.* – Development and occurrence of the *Cortuso matthioli-Piceetalia* communities is dependent on trophically very favourable properties of soils which are neutral to slightly acidic (Šoltés, 1976), with intensive nitrification (Hadač et al., 1969). Soil pH could fall under 6 in deeper non-skeletal soils (Hadač et al., 1969). The soils are rendzinas (rendzic leptosols), pararendzinas (subgroup of rendzic leptosols) to cambisols (calcaric cambisols) which could be decalcified and acidified, however, deeper in the soil horizon they are at least neutral or slightly acidic (cf. Šály, 1986). The respective habitats are therefore found in mountain regions formed by carbonate rocks. In areas with extreme relief litosols (lithic leptosols) could be present.

Nutrient supply could be blocked by thicker humus layer developed on small areas within some communities: calcifuges are bound to such places (*Vaccinium myrtillus*). Only sporadically, on exceptionally favourable habitats, phytocoenoses of the order *Cortuso matthioli-Piceetalia* could develop on weathered non-carbonate rocks, generally on habitats influenced by increased moisture and nutrient supply.

*Syntaxonomical delimitation.* – Communities of the order *Cortuso matthioli-Piceetalia* are here divided to four basic subunits which are given the rank of an alliance.

(A) The alliance ***Cortuso matthioli-Piceion abietis* P. Kučera 2022** (see below) comprises calcicolous *Picea abies* woodland types of the supramontane vegetation zone mainly of the Central European mountain ranges, with overlaps from the western (western Alps) to the southeastern part of the continent (Southern Carpathians).[14] The question of the syntaxonomical classification of Norway

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[14] In the western half of the Alps *Pinus uncinata* Ramond ex DC s. str. could be admixed in more extreme habitats (cf. Ellenberg & Klötzli, 1972; Schmider & Burnand, 1988).

spruce communities of the montane altitudes of the Dinaric mountain ranges (cf. Wraber, 1964; Wraber, 1969; Horvat et al., 1974; Zupančič, 1980; Accetto, 1993; Vukelić et al., 2010; Juvan et al., 2013 etc.) needs to be resolved in more detail: the refugial and relict occurrence of *Picea abies* (growing within mixed woodland phytocoenoses with *Abies*, *Acer*, *Fagus* etc., i.e. more or less marginal *Carpino-Fagetea* communities) should be carefully differentiated from the relict extragradal montane *Cortuso matthioli-Piceetalia* communities.

(B) Calcicolous *Picea abies* woodlands are replaced by calcicolous *Pinus cembra* or mixed *Pinus cembra* woodlands (mostly with *Larix decidua*) in the high mountain altitudes of the Alps as well as of the highest mountain ranges of the Carpathians (e.g. the Tatra Mountains). They are separated into the alliance ***Calamagrostio variae-Pinion cembrae* P. Kučera 2017** based on phytocoenoses from the Belianske Tatry Mts (Western Carpathians). The respective woodland stands were significantly negatively influenced by historical land management and only their fragments were preserved or they are completely missing in large continuous areas (cf. Kanka, 2008; Zięba et al., 2018; Zięba et al., 2019; Kučera & Barančok, 2021). Similar process could be presupposed also for large areas of the Alps outside of regions where the continuous Arolla pine woodlands were preserved up to the 20th century.

(C) Geographically vicariant unit of the Pyrenees is the alliance ***Seslerio caeruleae-Pinion uncinatae* Vigo 1974** (cf. Rivas-Martínez et al., 2001) with supramontane (to altimontane) plant communities formed by *Pinus uncinata* Ramond ex DC s. str. (and *Abies alba*). Data on the occurrence of phytocoenoses of this alliance in the northern Apennines (Angelini et al., 2009; Biondi et al., 2014) are questionable from the syntaxonomical as well as ecological point of view: from this region only the occurrence of *Pinus mugo* s. str. is indicated (cf. Gentile, 1995; Adorni, 2016; Pignatti et al., 2017).

(D) Occurrence of phytocoenoses floristically and ecologically belonging to the order *Cortuso matthioli-Piceetalia* is also indicated from the northern Europe (cf. Kielland-Lund, 1981; Dierßen & Dierßen, 1996). They syntaxonomically belong to the alliance ***Melico nutantis-Piceion* (Kielland-Lund 1981) P. Kučera stat. nov. hoc loco** (basionym: suballiance *Melico-Piceenion* Kielland-Lund 1981; see Kielland-Lund, 1981, p. 150, 176, 196).[15] However, similarly as in the Western Carpathians (see above p. 111–116), impacts of historical land management on the tree species composition of the Scandinavian woodlands should be carefully considered as *Picea abies* forests of the lower altitudes often represent secondary, substitutionary stands replacing potential natural mixed broadleaved forests of *Quercus*, *Fagus*, *Acer* spp.

(E) On the contrary, into the order *Cortuso matthioli--Piceetalia* (= *Athyrio-Piceetalia* auct. non Hadač 1962) do not belong various syntaxonomical units even if they are traditionally classified under the order name "*Athyrio-Piceetalia* Hadač 1962". For example, Sýkora (1971) differentiated a new alliance *Athyrio alpestris-Piceion* Sýkora 1971 within the order *Athyrio-Piceetalia* Hadač 1962. It is not clear whether he used the original or the pseudonymical concept of the order name (cf. Kučera, in red.); however, if the only subordinated association *Athyrio alpestris-Piceetum* Hartmann ex Sýkora 1971 nom. illeg. (Art. 31, later synonym of *Athyrio alpestris-Piceetum* Hartmann ex Hartmann et Jahn 1967) is considered as a syntaxon of natural *Picea abies* woodland then it floristically belongs to the alliance *Piceion abietis* Pawłowski ex Pawłowski et al. 1928 nom. corr. (syntax. syn. *Athyrio alpestris-Piceion* Sýkora 1971) (cf. Šomšák, 1983; Exner, 2007; Kučera, 2010a; Kučera, 2010c; Kučera, 2012a; Chytrý et al., 2013b).

(F) As indicated above (p. 111–116), many *Picea abies* forest stands of the Western Carpathians are secondary, anthropogenic forest communities with the spontaneous secondary succession of *Fagus sylvatica*, and they should be syntaxonomically classified within the class *Carpino--Fagetea*. Besides the respective *Picea* forests, there were described some *Abies alba* syntaxa of the higher rank which are traditionally considered as *Vaccinio-Piceetea* syntaxa. Below are given some examples of units (or their common interpretation) which syntaxonomically do not belong into the order *Cortuso matthioli-Piceetalia* (= *Athyrio-Piceetalia* auct. non Hadač 1962).

(F1) Hadač (Hadač, 1962; Hadač, 1965, see also Hadač et al., 1969) differentiated an independent alliance *Abietion albae* within the order "*Athyrio-Piceetalia* Hadač 1962". This new syntaxon was proposed for *Abies alba*- and mixed *Abies alba-Picea abies* communities distributed in the southeastern part of the Belianske Tatry Mts (northern Slovakia) and the surrounding regions. Hadač considered them for natural coniferous woodlands with naturally absent *Fagus sylvatica* due to continental

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[15] As Rivas-Martínez et al. (2011, p. 457) typified their name *Linnaeo-Piceion abietis* (Br.-Bl. et Sissingh in Br.-Bl. et al. 1939) Rivas-Mart. in Rivas-Mart. et al. 2011 nom. illeg. (Art. 31) with the association name *Piceetum fennnoscandicum* Br.-Bl. in Br.-Bl. et al. 1939, that alliance name became a syntaxonomical synonym to calcicolous *Melico nutantis-Piceion* (Kielland-Lund 1981) P. Kučera 2022: cf. the frequencies of species *Geranium sylvaticum*, *Fragaria vesca*, *Melica nutans*, *Paris quadrifolia*, *Convallaria majalis* within the original diagnosis of the association *Piceetum fennnoscandicum* Br.-Bl. in Br.-Bl. et al. 1939 (Braun-Blanquet et al., 1939, p. 53–54; cf. also Kielland-Lund, 1981, tab. 39).

climatic conditions. His concept was accepted in later Slovak regional or national surveys up to the present (for more detailed list see Kučera. in red.).

However, the factor which actually hindered the presence of *F. sylvatica* in the respective territory was historical land management, not presupposed continental climate. The supposed natural beechless character of the *Abietion albae* Hadač 1965 plant communities is of anthropogenic origin and they have to be classified within the class *Carpino-Fagetea* (Kučera, 2007; Kučera, 2010b; Kučera, 2012a; Kučera, 2012b and other works).

(F2) In the recent phytocoenological survey of the Austrian woodlands, Exner (2007) differentiated a special group of "dry carbonate *Picea abies*(-*Abies alba*) woodlands", classified as the suballiance *Calamagrostio variae-Abietenion* (Horvat 1962) Exner et Willner in Willner et al. 2007 within the class *Vaccinio-Piceetea*. However, the values of *Fagus sylvatica* frequency in the individual Austrian communities of this suballiance and, especially, increase in frequency of *Fagus* in the understorey in contrast to the canopy of the respective communities (see also *Acer pseudoplatanus*) as well as considerable decrease of frequency of *Larix decidua* (cf. Willner et al., 2007, tab. 33) indicate that spontaneous secondary succession takes place in the respective habitats and their tree species composition was substantially anthropogenically influenced.

Similarly like in the case of *Abietion albae* Hadač 1965 (see above), most of the respective secondary communities with anthropogenically lowered presence of *F. sylvatica* syntaxonomically belong to the class *Carpino-Fagetea.* Further research is needed to determine which Austrian regions exactly constitute the territory where *F. sylvatica* should be ultimately missing only due to natural reasons (e.g. a special intramountain climate). Corresponding *Abies alba* communities of the alliance *Calamagrostio-Abietion* Horvat 1962 nom. invers. in the Dinarides (Horvat, 1962; Horvat et al., 1974) should also be revised for historical anthropogenic influences and potential secondary succession of *Fagus*.

(F4) Similarly to the previous group, Austrian communities of *Abieti-Piceenion* Br.-Bl. in Br.-Bl. et al. 1939 (see Exner, 2007) represent for the substantial part anthropogenically influenced mixed forests with secondary succession of *Fagus* (cf. synoptic table No. 33 in Willner et al. (2007)) therefore the respective phytocoenoses should be classified within the class *Carpino-Fagetea*.

The nomenclatural type of the alliance *Abieti-Piceion* (Br.-Bl. in Br.-Bl. et al. 1939) Soó 1963/ *Abieti-Piceenion* Br.-Bl. in Br.-Bl. et al. 1939 – the association *Piceetum montanum* Br.-Bl. in Br.-Bl. et al. 1939 (Willner, 2007, p. 237) – also represents mixed coniferous forest with anthropogenically induced absence of *F. sylvatica*. The original diagnosis of this association consists of six published relevés of Beger (1922) from the Schanfigg Valley in the eastern Switzerland and from seven unpublished relevés of J. Braun-Blanquet. Although Beger (1922, p. 70) published only such phytocoenological relevés in which *F. sylvatica* is admixed, there exists also ca. pure *F. sylvatica* stand in the vicinity of Tschiertschen (coordinates 46°49'33" N, 9°35'55" E, cca up to 1120 m a.s.l., cf. Google Earth). Fertile *Fagus* trees in this region were recorded even at 1330 m a.s.l. by Beger (1922).

Beger's relevés of Norway spruce communities from the lower montane altitudes represent secondary forests which developed under the millenia of human influence (the region is considerably deforested till the present) and as such they should be classified similarly as the *Abietion albae* Hadač 1965 communities of the northern Slovakia (Hadač, 1965; Hadač et al., 1969) within the class *Carpino-Fagetea* (cf. Hadač & Sofron, 1980). Subsequently, the alliance should be classified with the respect to its original diagnosis in the same way as already Oberdorfer (1957) proposed.[16]

It seems that the spatial delimitation of the so-called "Zwischenalpen zone", i.e. the territory where *F. sylvatica* should be naturally absent (on the contrary to "Randalpen zone") and *Picea abies* and *Abies alba* form forests in the montane altitudes (Kuoch, 1954; Ellenberg, 1996; cf. Lauber et al., 2018) (see also Mayer & Hofmann, 1969; Mayer, 1974; Mayer, 1984; Sauberer & Willner, 2007), have to be substantially revised with serious consideration of the impacts of historical land management: the above mentioned Schanfigg Valley is commonly classified as the part of the Zwischenalpen zone, according Ellenberg & Klötzli (1972) even within the Zentralalpen zone; however, the preserved *Fagus* stand by Tschiertschen and other *Fagus* occurrences towards the valley¨ opening contradict to such geobotanical classification (cf. Hess et al., 1967, p. 63).

In the Western Carpathians, an analogous *Fagus*-free "intramountain zone" was traditionally recognized; however, supposed natural absence of *Fagus* is, in fact, result of pre-/historical land management of the respective landscape, i.e. the intermountain basins of the Liptovská kotlina and the Popradská kotlina as well as the adjacent slopes of the surrounding mountain ranges (see Krippel, 1963; Kučera, 2012b).

(F5) Mucina et al. (2016) listed the alliance name *Abietion albae* Issler 1931 as a synonym of the alliance

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[16] In respect of the characteristics of the altitudinal distribution of the association *Piceetum montanum* Br.-Bl. in Br.-Bl. et al. 1939 and its original table by Braun-Blanquet et al. (1939, p. 15), the following typification is proposed for nomenclatural reasons: *Piceetum montanum* Br.-Bl. in Br.-Bl. et al. 1939 [Braun-Blanquet et al. 1939, p. 14] Nomenclatural type: Beger 1922, p. 49–50, rel. No. 3, lectotypus hoc loco.

*Abieti-Piceion* (Br.-Bl. in Br.-Bl. et al. 1939) Soó 1964 (cf. Willner, 2007, p. 237) which was presented as "Mesophilous fir forests on brown forest soils …". However, the original diagnosis of the alliance *Abietion albae* Issler 1931 (Issler, 1926, tab. VI; Issler, 1931) clearly shows that the author classified in the respective units mixed *Abies-Fagus* communities, probably also considerably influenced by historical land management (see differences of *Fagus* abundance between canopy and understorey). They syntaxonomically belong to the class *Carpino-Fagetea* (cf. Boeuf et al., 2014).

Slightly different is the case of the alliance *Piceo--Abietion* Ellenberg et Klötzli 1974 nom. inval. (Art. 3b), however, already the original authors classified their unit within the class *Carpino-Fagetea* (ut "*Querco-Fagetea*", Ellenberg & Klötzli (1972), see also above "F4"). It should be also noted that Czech and Moravian phytocoenologists classify *Abies alba* forests within the class *Carpino--Fagetea* (Moravec et al., 2000; Boublík et al., 2013).

## *Cortuso matthioli-Piceion abietis* P. Kučera all. nov. hoc loco

Nomenclatural type: *Cirsio erisithalis-Piceetum abietis* Fajmonová et P. Kučera in P. Kučera 2022 (see above p. 127), holotypus hoc loco.

Syntax. syn.: *Piceion excelsae* Sillinger 1933 p. p. min.

Pseudonyms (see Kučera in red.): *Chrysanthemo-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962, *Oxalido-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962

Original diagnosis (see the p. 119–136): *Seslerio caeruleae--Piceetum abietis* Fajmonová 1978 nom. corr. et nom. cons. propos., *Cirsio erisithalis-Piceetum abietis* Fajmonová et P. Kučera in P. Kučera 2022, *Fragario vescae--Piceetum abietis* P. Kučera 2022 ass. prov., *Adenostylo alliariae-Piceetum abietis* Samek et al. 1957 nom. corr. et nom. cons. propos., *Mnio spinosi-Piceetum abietis* Hadač et al. 1969 nom. corr. (incl. *Oxalido-Piceetum* Březina et Hadač in Hadač et al. 1969), *Hieracio murorum-Piceetum abietis* P. Kučera 2022

Differential species (see Table 5):[17]

$E_1$: *Myosotis sylvatica*, *Primula elatior*, *Fragaria vesca*, *Senecio nemorensis* agg., *Galeobdolon luteum* agg., *Astrantia major*, *Mercurialis perennis*, *Dryopteris filix-mas*, *Sesleria albicans*, *Heracleum sphondylium*, *Pyrethrum clusii*, *Chaerophyllum hirsutum*, *Epilobium montanum*, *Lilium martagon*, *Milium effusum*, *Paris quadrifolia*, *Rubus saxatilis*, *Pimpinella major*, *Cirsium erisithales*, *Ranunculus lanuginosus*, *Dentaria enneaphyllos*, (*Soldanella carpatica*, *Cicerbita alpina*, *Mycelis muralis*, *Crepis paludosa*);

$E_0$: (*Tortella tortuosa*, *Ctenidium molluscum*).

*Floristical delimitation and characteristics.* – Phytocoenoses of the order *Cortuso matthioli-Piceetalia* in the Western Carpathians are divided into two altitudinally and phytochorologically different geobotanical groups with diverse postglacial and pre-/historical development. While the Arolla pine woodlands of the alliance *Calamagrostio variae-Pinion cembrae* survived only in the most highest mountain ranges and even there its stands were preserved only in small isolated islands (cf. Kanka, 2008; Zięba et al., 2018; vs. Kučera, 2019b; Kučera & Barančokc, 2021) due to extensive deforestation for high mountain grazing, the *Cortuso-Piceion* woodlands participate on formation of the distinct altitudinal vegetation zone developed in all higher mountain ranges with adequate total elevations (however, large continuous areas were deforested too).

The most noticeable differential feature of the *Cortuso matthioli-Piceion* phytocoenoses is the natural absence of mature *Pinus cembra* trees. Other species bound to high mountain altitudes are also (mostly) missing in *Cortuso matthioli-Piceion*: *Rhodiola rosea*, *Festuca versicolor*, *Hedysarum hedysaroides*, *Salix retusa* etc. For the list of positive differential species see the Table 5. Lower constancies of *Vaccinium vitis-idaea*, *Huperzia selago*, *Avenella flexuosa* in *Cortuso matthioli-Piceion* stands are caused by generally less extreme habitats and thinner accumulations of raw humus as well as probably only very sporadic development of tangel humus; however, anthropogenic absence of *Pinus cembra* woodlands on ecologically medium habitats with deeper calcareous soils causes certain species bias in the presented floristical comparison of the Table 5.

The canopy dominant of the *Cortuso matthioli-Piceion* woodlands is *Picea abies* to which other species are admixed, most frequently *Sorbus aucuparia* (usually ssp. *glabrata*). Not seldom *Acer pseudoplatanus* grows in the stands, in the ecologically more extreme habitats *Sorbus aria* is present. Natural presence of *Abies alba* is presupposed in the lower elevations of the altitudinal distribution of the *Cortuso matthioli-Piceion* woodlands, with occurrence of *Fagus sylvatica* is counted only at lower altitudinal limit of Norway spruce altitudinal vegetation zone and only with specimens of low growth which do not have ecological impact on development and species diversity of plant communities. In the region of the Tatra Mountains and the Low Tatras autochthonous *Larix decidua* was originally perhaps more represented in the stands, especially in more extreme habitats (in the similar way prob-

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[17] Species with the fidelity value lower that "33" are in brackets.

**Table 5:** Differential table of the alliances of the order *Cortuso matthioli-Piceetalia* P. Kučera 2022 ord. nov. in Slovakia with values of constancy (%) and fidelity (φ × 100) in the exponent.

**Tabela 5:** Diferencialna tabela zvez redu *Cortuso matthioli-Piceetalia* P. Kučera 2022 ord. nov. na Slovaškem s prikazano stalnostjo (%) in nadpisano navezanostjo (φ × 100).

The relevé dataset is identical with the Table 2 (synoptic table of the order *Cortuso matthioli-Piceetalia*) compiled by Kučera (in prep.).

Species with fidelity value (φ × 100) lower than 25 are omitted.

Group 1 – *Cortuso matthioli-Piceion abietis* P. Kučera 2022 ord. nov., Group 2 – *Calamagrostio variae-Pinion cembrae* P. Kučera 2017

| Group No. | 1 | 2 |
|---|---|---|
| No. of relevés | 80 | 15 |
| **Tree and shrub species** | | |
| **$E_3$** | | |
| *Pinus cembra* | $.^{-}$ | $\mathbf{100}^{\mathbf{100.0}}$ |
| *Betula carpatica* | $.^{-}$ | $40^{\mathbf{50.0}}$ |
| *Sorbus aucuparia* | $35^{-}$ | $\mathbf{67}^{31.7}$ |
| **$E_2$** | | |
| *Picea abies* | $20^{-}$ | $\mathbf{67}^{47.1}$ |
| *Sorbus aucuparia* | $29^{-}$ | $\mathbf{73}^{44.6}$ |
| *Pinus cembra* | $.^{-}$ | $27^{39.2}$ |
| *Betula carpatica* | $1^{-}$ | $20^{30.4}$ |
| *Pinus mugo* | $14^{-}$ | $40^{29.6}$ |
| *Lonicera nigra* | $4^{-}$ | $20^{25.1}$ |
| **$E_1$** | | |
| *Pinus cembra* | $1^{-}$ | $47^{\mathbf{53.2}}$ |
| *Sorbus aucuparia* | $\mathbf{64}^{-}$ | $\mathbf{100}^{47.1}$ |
| *Betula carpatica* | $.^{-}$ | $27^{39.2}$ |
| *Picea abies* | $32^{-}$ | $\mathbf{60}^{27.6}$ |
| **Field layer species ($E_1$)** | | |
| *Myosotis sylvatica* | $\mathbf{56}^{\mathbf{62.6}}$ | $.^{-}$ |
| *Primula elatior* | $\mathbf{64}^{\mathbf{51.8}}$ | $13^{-}$ |
| *Fragaria vesca* | $38^{48.0}$ | $.^{-}$ |
| *Senecio nemorensis* agg. | $\mathbf{79}^{45.8}$ | $33^{-}$ |
| *Galeobdolon luteum* agg. | $46^{44.9}$ | $7^{-}$ |
| *Astrantia major* | $45^{43.8}$ | $7^{-}$ |
| *Mercurialis perennis* | $31^{43.0}$ | $.^{-}$ |
| *Dryopteris filix-mas* | $44^{42.7}$ | $7^{-}$ |
| *Sesleria caerulea* | $30^{42.0}$ | $.^{-}$ |
| *Heracleum sphondylium* | $41^{40.5}$ | $7^{-}$ |
| *Pyrethrum clusii* | $26^{38.9}$ | $.^{-}$ |
| *Chaerophyllum hirsutum* | $36^{36.0}$ | $7^{-}$ |
| *Epilobium montanum* | $36^{36.0}$ | $7^{-}$ |
| *Lilium martagon* | $22^{35.6}$ | $.^{-}$ |
| *Milium effusum* | $21^{34.5}$ | $.^{-}$ |
| *Paris quadrifolia* | $21^{34.5}$ | $.^{-}$ |
| *Rubus saxatilis* | $21^{34.5}$ | $.^{-}$ |
| *Pimpinella major* | $21^{34.5}$ | $.^{-}$ |
| *Cirsium erisithales* | $44^{33.7}$ | $13^{-}$ |
| *Ranunculus lanuginosus* | $20^{33.3}$ | $.^{-}$ |
| *Dentaria enneaphyllos* | $20^{33.3}$ | $.^{-}$ |
| *Soldanella carpatica* | $32^{32.5}$ | $7^{-}$ |
| *Cicerbita alpina* | $42^{32.5}$ | $13^{-}$ |
| *Mycelis muralis* | $40^{30.2}$ | $13^{-}$ |
| *Crepis paludosa* | $39^{29.0}$ | $13^{-}$ |
| *Vaccinium vitis-idaea* | $22^{-}$ | $\mathbf{93}^{\mathbf{71.7}}$ |
| *Campanula rotundifolia* agg. | $12^{-}$ | $\mathbf{73}^{\mathbf{61.5}}$ |
| *Cystopteris montana* | $9^{-}$ | $\mathbf{67}^{\mathbf{59.8}}$ |
| *Cystopteris fragilis* | $12^{-}$ | $\mathbf{60}^{49.4}$ |
| *Huperzia selago* | $10^{-}$ | $\mathbf{53}^{46.6}$ |
| *Sesleria tatrae* | $6^{-}$ | $\mathbf{47}^{45.8}$ |
| *Avenella flexuosa* | $44^{-}$ | $\mathbf{87}^{45.1}$ |
| *Bistorta major* | $2^{-}$ | $33^{40.2}$ |
| *Rhodiola rosea* | $2^{-}$ | $33^{40.2}$ |
| *Gymnocarpium dryopteris* | $16^{-}$ | $\mathbf{53}^{38.9}$ |
| *Festuca versicolor* | $.^{-}$ | $20^{33.3}$ |
| *Hedysarum hedysaroides* | $.^{-}$ | $20^{33.3}$ |
| *Dryopteris carthusiana* agg. | $49^{-}$ | $\mathbf{80}^{32.6}$ |
| *Calamagrostis varia* | $36^{-}$ | $\mathbf{67}^{30.4}$ |
| *Pyrola rotundifolia* | $1^{-}$ | $20^{30.4}$ |
| *Myosotis alpestris* | $1^{-}$ | $20^{30.4}$ |
| *Luzula luzuloides* | $24^{-}$ | $\mathbf{53}^{30.4}$ |
| *Salix retusa* | $.^{-}$ | $13^{26.7}$ |
| *Salix reticulata* | $.^{-}$ | $13^{26.7}$ |
| *Bistorta vivipara* | $.^{-}$ | $13^{26.7}$ |
| *Astragalus norvegicus* | $.^{-}$ | $13^{26.7}$ |
| *Ranunculus alpestris* | $.^{-}$ | $13^{26.7}$ |
| *Saxifraga wahlenbergii* | $.^{-}$ | $13^{26.7}$ |
| *Helianthemum grandiflorum* | $.^{-}$ | $13^{26.7}$ |
| *Androsace chamaejasme* | $.^{-}$ | $13^{26.7}$ |
| *Gentiana punctata* | $.^{-}$ | $13^{26.7}$ |
| *Bartsia alpina* | $.^{-}$ | $13^{26.7}$ |
| *Dryas octopetala* | $.^{-}$ | $13^{26.7}$ |
| *Saxifraga paniculata* | $.^{-}$ | $13^{26.7}$ |
| *Moehringia muscosa* | $.^{-}$ | $13^{26.7}$ |
| **Ground layer species ($E_0$)** | | |
| *Tortella tortuosa* | $29^{41.0}$ | $.^{-}$ |
| *Ctenidium molluscum* | $28^{39.9}$ | $.^{-}$ |
| *Plagiothecium undulatum* | $.^{-}$ | $13^{26.7}$ |
| *Mylia taylorii* | $.^{-}$ | $13^{26.7}$ |
| *Ptilidium ciliare* | $.^{-}$ | $13^{26.7}$ |

ably also *Betula carpatica*). The current *Larix* abundance is increased (or on the contrary decreased) by silvicultural interventions and by historical land management.

Regular components of the understorey are in particular species *Daphne mezereum*, *Lonicera nigra*, *Ribes petraeum* and *R. alpinum*. *Pinus mugo* naturally occurs on more rocky habitats.

Characteristic feature of the prevalent part of communities of the alliance *Cortuso matthioli-Piceion* is the high species diversity (sporadically over 80 species in one relevé). Important part of the field layer of phytocoenoses is presence of calciphytes, for example *Cirsium erisithales*, *Asplenium viride*, *Bellidiastrum michelii*, *Cardaminopsis arenosa* agg., *Rubus saxatilis*, *Pimpinella major*, in some cases they are dominant components of stands *Calamagrostis varia*, *Cortusa matthioli*, *Sesleria albicans*.

Distinctive diagnostic feature of the alliance *Cortuso matthioli-Piceion* against the alliance *Piceion abietis* Pawłowski ex Pawłowski et al. 1928 (order *Piceetalia abietis* Pawłowski ex Pawłowski et al. 1928) is also the presence of very numerous group of species which almost exclusively grows only in the former alliance when considering the communities of natural mountain Norway spruce woodlands. This group consists of species which require nutrient-rich habitats, for example *Valeriana tripteris*, *Primula elatior*, *Polygonatum verticillatum*, *Phyteuma spicatum*, *Myosotis sylvatica*, *Geranium sylvaticum*, *Heracleum sphondylium*, *Fragaria vesca*, *Mercurialis perennis*, *Lilium martagon*, *Thalictrum aquilegiifolium*, *Paris quadrifolia*, *Dentaria enneaphyllos* and many more.

Species common in the so-called acid Norway spruce woodlands, and usually common in lower lying upper montane mixed *Fagus* woodlands as well, e.g. *Oxalis acetosella*, *Luzula sylvatica* ssp. *sylvatica*, *Homogyne alpina*, *Prenathes purpurea*, *Dryopteris dilatata*, *D. expansa*, are also abundant in the phytocoenoses of the alliance *Cortuso-Piceion*. *Adenostyles alliariae* is a field layer dominant of subunits of the various floristically and ecologically distinct communities. Outspoken calcifuges (*Vaccinium myrtillus*, *Avenella flexuosa*, *Calamagrostis villosa*, *V. vitis-idaea* a pod.) usually reach only low cover values or they are completely missing.

For the ground layer of the *Cortuso matthioli-Piceion* woodlands presence of species *Mnium spinosum*, *Tortella tortuosa*, *Ctenidium molluscum*, *Plagiochila asplenioides*, *Rhizomnium punctatum* is characteristic. Common woodland species *Dicranum scoparium*, *Hylocomium splendens*, *Plagiothecium curvifolium*, *Rhytidiadelphus triquetrus*, *Polytrichum formosum* and others are usually present as well.

*Nomenclatural note.* – The alliance names "*Chrysanthemo-Piceion* Březina et Hadač in Hadač 1962" as well as "*Oxalido-Piceion* Březina et Hadač in Hadač 1962" were used in the previously published regional and international surveys for the respective syntaxon of calcicolous natural Norway spruce woodlands. As Kučera (in red.) extensively explained, the original diagnoses of these syntaxa considerably differ from their traditional use which corresponds to their application as pseudonyma *Chrysanthemo-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962 and *Oxalido-Piceion* auct. non (Krajina 1933) Březina et Hadač in Hadač 1962.

Therefore new name *Cortuso matthioli-Piceion abietis* was proposed to replace the mentioned pseudonyma. The proposal to establish such new alliance represent a return to the previous conception of Kučera (2007).

# Conclusions

The second version and at the same time third part of the syntaxonomical revision of the communities traditionally classified within the class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 from the territory of the Slovak Western Carpathians is presented. It is dedicated to Norway spruce woodlands which are classified within the order *Cortuso matthioli-Piceetalia* (= *Athyrio-Piceetalia* auct. non Hadač 1962). The revision is based on careful data selection made in effort to separate the natural supramontane Norway spruce woodlands from the secondary *Picea abies* phytocoenoses in which evident secondary succession of *Fagus sylvatica* is in progress and which as such belong to the class *Carpino-Fagetea* Jakucs ex Passarge 1968. The variety of the Western Carpathian Norway spruce vegetation types found on carbonate rocks in habitat series from the most extreme habitats with shallow soils to more deep soils decalcified in the upper soils horizon is classified within six associations arranged in the following scheme:

*Cortuso matthioli-Piceetalia abietis* P. Kučera 2022 ord. nov.

*Cortuso matthioli-Piceion abietis* P. Kučera 2022 all. nov.

1. *Seslerio caeruleae-Piceetum abietis* Fajmonová 1978 nom. corr. et nom. cons. propos.
2. *Cirsio erisithalis-Piceetum abietis* Fajmonová et P. Kučera in P. Kučera 2022
3. *Fragario vescae-Piceetum abietis* P. Kučera 2022 ass. nov. prov.
4. *Adenostylo alliariae-Piceetum abietis* Samek et al. 1957 nom. corr. et nom. cons. propos.
5. *Mnio spinosi-Piceetum abietis* Hadač et al. 1969 nom. corr.
6. *Hieracio murorum-Piceetum abietis* P. Kučera 2022 ass. nov.

# Acknowledgments

My sincere thanks belong to R. Bouef for valuable help with literature, especially old *Fagus*- and *Abies*-syntaxa names as well as to librarians of the Slovak National Library in Martin and to librarians I. Pekárová and I. Gažiová (Institute of Botany SAS, Bratislava). I would like to also thank to J.-P. Theurillat for the various nomenclatural advices provided in the recent years and to Ch. Schaffer of the Revierforstamt Tschiertschen-Praden for confirmation of the existence of *Fagus* woodland near Tschiertschen (Switzerland). Finally, I would like to thank to the anynomous reviewers for their correction to the manuscript and especially for their inspiring comments.

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# Funding

This study was funded by the Slovak grant agency VEGA, project No. 2/0119/19.

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