

Wet meadows with Purple Moor-grass (*Molinia caerulea*) in Slovenia

Mokrotni travniki z modro stožko (*Molinia caerulea*) v Sloveniji

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Abstract: The paper presents wet meadow vegetation with taxon *Molinia caerulea* (L.) Moench subsp. *caerulea* in Slovenia. The main objective of this study was to examine the plant species composition and plant species richness of wet meadow plant communities with the mentioned dominating or co-dominating plant taxon. Vegetation was recorded in accordance with standard Central European method. Vegetation types were classified by means of multivariate analysis. Four associations from the alliance *Molinon* Koch 1926 were identified and analysed: *Plantagini altissimae-Molinietum caeruleae* Marchiori & S Burlino 1982, *Selino-Molinietum caeruleae* Kuhn 1937, *Carici davallianae-Molinietum caeruleae* Špániková 1978 and *Junco-Molinietum caeruleae* Preising 1951 ex Klapp 1954. Ecological characteristics, plant species composition and richness of the delimited plant communities are presented, as well as their syntaxonomic position and distribution. For two of the mentioned communities relevés made in Slovenia are published here for the first time.

Keywords: *Molinia caerulea* (L.) Moench subsp. *caerulea*, plant species composition, vegetation ecology, wetlands

Izveček: V prispevku je predstavljena vegetacija mokrotnih travnikov s taksonom *Molinia caerulea* (L.) Moench subsp. *caerulea* v Sloveniji. Glavni cilj je bil preučiti floristično sestavo in vrstno pestrost rastlinskih združb na mokrotnih travnikih z omenjenim dominantnim ali ko-dominantnim taksonom. Vegetacija smo popisali po standardni srednjeevropski metodi. Vegetacijske tipe smo uvrstili v sintaksonomski sistem s pomočjo multivariatnih analiz. Določili in analizirali smo štiri asociacije iz zveze *Molinon*: *Plantagini altissimae-Molinietum caeruleae* Marchiori & S Burlino 1982, *Selino-Molinietum caeruleae* Kuhn 1937, *Carici davallianae-Molinietum caeruleae* Špániková 1978 in *Junco-Molinietum caeruleae* Preising 1951 ex Klapp 1954. Predstavljene so ekološke značilnosti, floristična sestava in vrstna pestrost navedenih rastlinskih združb kot tudi njihov sintaksonomski položaj in razširjenost. Za dve rastlinski združbi popise, narejene v Sloveniji, tukaj objavljamo prvič.

Ključne besede: *Molinia caerulea* (L.) Moench subsp. *caerulea*, floristična sestava, vegetacijska ekologija, mokrišča

Introduction

Wet meadows and other similar wetland-types have been the object of several studies throughout Europe in the last decade (Hájek and Hájková 2004, Havlová et al. 2004, Hölzel and Otte 2004, Hrivnák 2004, Grootjans et al. 2005, Stančič 2005, Zelnik 2005a,b, Hájková et al. 2006, Havlová 2006, Řezníčková 2007, Janišová et al. 2007, Stančič 2008, Zelnik and Čarni 2008a,b), since the threat to the biodiversity of these ecosystems is still increasing and numerous sites have been destroyed, respectively.

Meadows of the alliance *Molinion* Koch 1926 are found in nutrient-poor soils (Hölzel and Otte 2004), which may dry up during the summer (Botta-Dukát et al. 2005). They thrive on permanently to alternatively wet soils, which are acid, or alkaline (Ellmauer and Mucina 1993).

These oligotrophic ecosystems need management, which should be neither excessive nor lacking in its intensity (Ellmauer and Mucina 1993). In the last decades a decrease in biodiversity of wet meadows due to intensified agricultural use, namely the use of fertilizers has been detected (Ellmauer and Mucina 1993, Joyce 2001, McCrea et al. 2001).

Knowledge of the plant communities enables us to forecast the likely changes in floristic composition after changes of site factors (Grevilliot and Muller 2002). Nutrient availability and water regime are considered to be the most important factors determining the structure and properties of wet grassland vegetation (De Mars et al. 1996, van Duren and Pegtel 2000, Zelnik and Čarni 2008a).

Horvatić (1939) was the first researcher who systematically studied vegetation of the wet meadows in Slovenia. During the study of the vegetation of the lake Cerkniško jezero Iljanič (1979) described new plant association *Deschampsio-Plantaginetum altissimae*, and classified it to the alliance *Molinion*. He recorded stands of this vegetation type in Planinsko polje as well. Vegetation with *Molinia caerulea* in Ljubljana moor was studied by Seliškar (1986). Vegetation of the lake Cerkniško jezero was studied also by Martinčič (1991, 2001), who described new plant associations *Schoeno nigricantis-Molinietum caeruleae* Martinčič 1991 and *Schoeno ferruginei-Molinietum*

caeruleae Martinčič 2001 and classified them to the alliance *Molinion*. This type of vegetation on the Bloke plateau and in some other areas in Dinaric and Alpine regions was studied by Leskovar (1996). Kaligarič (1997) documented the thriving of the association *Selino-Molinietum caeruleae* Kuhn 1937 near Slovenj Gradec. Results of the studies of the wet meadows in SE Slovenia (Krško basin, Bela Krajina) are published in Zelnik (2005a), Zelnik and Čarni (2008b). Vegetation ecology of some of the communities from the alliance *Molinion* in Slovenia is discussed in Zelnik and Čarni (2008a).

Beside the mentioned publications that cover only some of the areas in Slovenia, wet meadow vegetation in major part of the country remained almost unknown to the scientific public, especially the presence, structure and distribution of several plant communities. One of the aims of this paper is to fill this gap and to present the characteristics and distribution of wet meadow plant communities with *Molinia caerulea* (Purple Moor-grass) in Slovenia. The aims of this study were also to examine:

- The structure and diversity of wet meadow plant communities with dominant taxon *Molinia caerulea* ssp. *caerulea*.
- Relationships between wet meadow communities of *Molinion* alliance in Slovenia and their distribution.

Material and methods

Study area

The meadows were investigated across the majority of the state, in the continental part of Slovenia from the western border of Dinaric region to the eastern border of the state, which is in the Pannonian region (from 14°10' to 16°20'E, from 45°40' to 46°50'N). There is a strong gradient in annual precipitation from the SW to NE part of the studied area. In the SW part the climate is more humid with an annual precipitation of 1500 mm, but in the NE part, which is the driest part of Slovenia the annual precipitation is 800 mm (Zupančič 1995). For this study vegetation plots from NE, E and SE parts of the state were excluded from analysis due to absence of the taxon *Molinia*

caerulea ssp. *caerulea*. Moreover, only stands with dominant or co-dominant mentioned taxon were considered for this study. There is also an altitudinal gradient which reflects in mean annual temperatures, as some plots can be found at about 265 m and others 680 m a.s.l., but the majority is found between 300 and 500 m a.s.l.

Vegetation analysis

Vegetation was investigated according to the standard Central European method (Braun-Blanquet 1964). The cover-abundance values were transformed according to van der Maarel (1979). Vegetation relevés (59) were made in the years 2003 and 2004. The size of plots varies from 15 to 25 m² due to micro-topography. Nomenclature of plant taxa follows Ehrendorfer et al. (1973) with exception of taxa *Centaurea macroptilon* Borb., *Centaurea carniolica* Host.

Similarity analyses of the relevés were carried out using the computer program SYN-TAX (Podani 2001); an ordination method (PCoA) was performed. Dissimilarity of relevés was measured with Similarity ratio complement. Rare species were not excluded from the analysis. Clusters of relevés were classified into syntaxa according to Ellmauer and Mucina (1993) as well as local studies (Zelnik 2005a,b).

Results and discussion

Floristically defined wet meadow communities

Since the objects of our study were stands with abundant taxon *Molinia caerulea* ssp. *caerulea*, the classification to the alliance *Molinion* could be done without any doubt. Further classification of the relevés was done on the base of the ordination diagram (Fig. 1), which shows the grouping of the relevés according to the similarity of their floristic composition. The four groups corresponded to four wet meadow plant associations belonging to *Molinion* alliance and were classified according to Ellmauer and Mucina (1993), Sburlino et al. (1995), Zelnik (2005a,b), Zelnik and Čarni (2008a): (1) *Plantagini altissimae-Molinietum caeruleae* Marchiori & Sburlino 1982, (2) *Selino-Molinietum*

caeruleae Kuhn 1937, (3) *Carici davallianae-Molinietum caeruleae* Špániková 1978 and (4) *Junco-Molinietum caeruleae* Preising 1951 ex Klapp 1954.

Despite the results of formalized classification of the stands with *Molinia caerulea*, that were obtained in several countries and are able to define only two different associations, we disagree with such simplification of this diverse vegetation in floristic and ecological sense that reflects in high species diversity and diversity of communities/ecosystems. Statistically significant differences in many measured and/or calculated ecological parameters between these associations were calculated and published (Zelnik and Čarni 2008a), so these clearly defined associations from the alliance *Molinion* obviously exist.

Syntaxonomical scheme of the studied vegetation:

- Molinio-Arrhenatheretea* R.Tx. 1937 em.
R. Tx. 1970
- Molinietalia* Koch 1926
- Molinion* Koch 1926
 - Plantagini altissimae-Molinietum caeruleae*
Marchiori & Sburlino 1982
 - Selino-Molinietum caeruleae* Kuhn 1937
 - Carici davallianae-Molinietum caeruleae*
Špániková 1978
 - Junco-Molinietum caeruleae* Preising 1951
ex Klapp 1954

The sampling plots in the ordination diagram were segregated according to communities (Fig. 1) and also correspond to the traditional method:

- *Plantagini-Molinietum* with the highest scores along the first axis (the most humid climate) and intermediate along the second axis;
- *Selino-Molinietum* with intermediate position that is in accordance with its central position within the alliance *Molinion*;
- *Carici-Molinietum* with the highest scores along the first axis (the highest pH) and moderate humidity;
- *Junco-Molinietum* with high scores along first axis (humid sites – depressions);

Their characteristic taxa are presented in Table 1, while their plant species composition is presented in Tables 2 and 3. In total 232 plant taxa were found in 59 sampled plots, ranging from 14 to 69 plant taxa per plot.

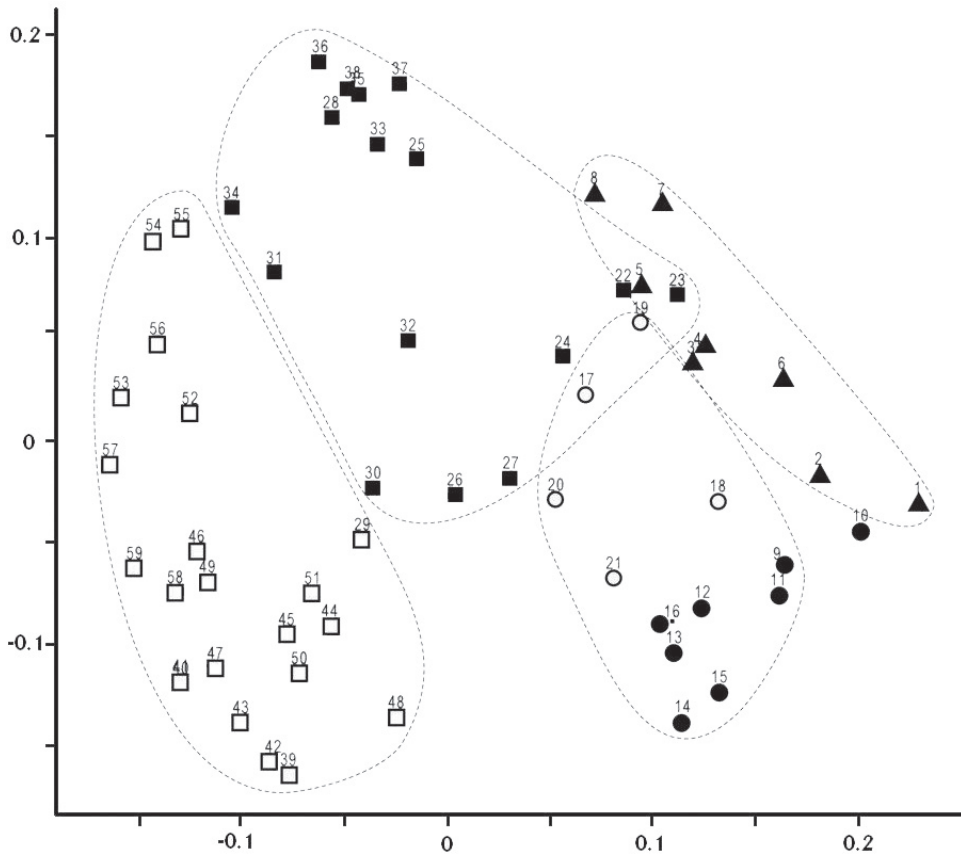


Figure 1: Ordination diagram of sampling plots based on analysis PCoA. Numbers correspond to the numbers of relevés in Tables 2-3 (complement of similarity ratio).

Slika 1: Ordinacijski diagram popisov na osnovi metode PCoA. Številke so v skladu s številkami popisov v Tabelah 2-3 (komplement koeficienta podobnosti).

- ▲ 1–8: *Plantagini altissimae-Molinietum caeruleae*,
- 9–16: *Junco-Molinietum caeruleae succisletosum inflexae*,
- 17–21: *Junco-Molinietum caeruleae typicum*,
- 22–38: *Selino-Molinietum caeruleae*,
- 39–59: *Carici davallianae-Molinietum caeruleae*.

***Plantagini altissimae-Molinietum caeruleae* Marchiori & Sbrulino 1982**

This association was described in eastern parts of Po plain (Veneto, Friuli), where it thrives in helocrenic spring sites and in higher parts of the lowland (Sbrulino et al. 1995). Stands often occur in depressions within intensively cultivated areas, where the mineralization of soil organic matter is hindered due to high water content (Sbrulino et al. 1995).

The association *Plantagini altissimae-Molinietum caeruleae* Marchiori & Sbrulino 1982 is found in the western part of studied area, where the climate is most humid and this is the main ecological difference with communities of the alliance *Deschampsion* Horvatić 1930, which thrive in the areas with more arid climate.

Stands classified to this association were recorded in the valley of river Nanošiča. They thrive in bigger depressions, which do not lie

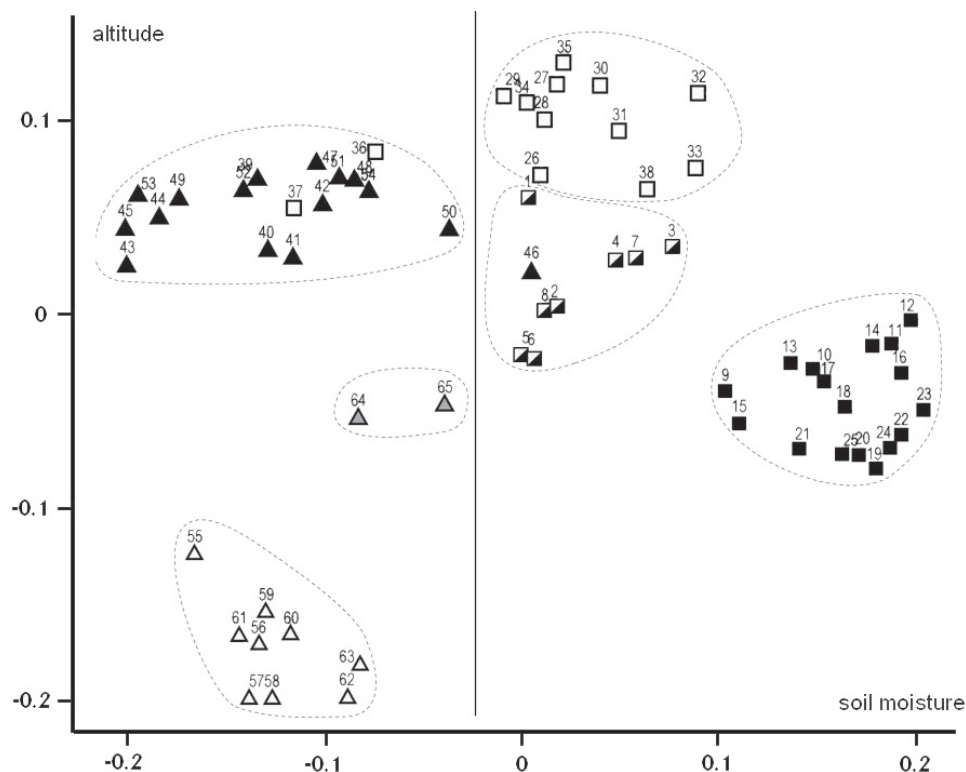


Figure 2: Ordination of the relevés of the associations *Plantagini altissimae-Molinietum caeruleae* and *Deschampsio-Plantagnetum altissimae* (PCoA, complement of similarity ratio):

Slika 2: Ordinacija popisov asociacij *Plantagini altissimae-Molinietum caeruleae* in *Deschampsio-Plantagnetum altissimae* (PCoA, komplement koeficienta podobnosti):

- 1–8: Zelnik, hoc loco, tab. 2 / 1–8 *Plantagini altissimae-Molinietum caeruleae*;
- 9–25: Sbrulino et al. (1995), tab. 1 / 1–17 *Plantagini altissimae-Molinietum caeruleae*;
- 26–37: Ilijanić (1979), tab. 11 / 1–12 *Deschampsio-Plantagnetum altissimae cirsietosum pannonicum*;
- ▲ 38–54: Ilijanić (1979), tab. 11 / 13–29 *Deschampsio-Plantagnetum altissimae typicum & filipenduletosum vulgare*;
- ▲ 55–63: Zelnik, 2005b, tab. 6 / 1–9 *Deschampsio-Plantagnetum altissimae caricetosum tomentosae*;
- ▲ 64–65: Zelnik, 2005b, tab. 6 / 10–11 *Deschampsio-Plantagnetum altissimae molinietosum arundinaceae*;

along the mentioned river on its floodplain, but along its tributaries that drain the areas on non-calcareous bedrock.

Characteristic species and plant species composition. Sbrulino et al. (1995) declared the species *Plantago altissima* as the only characteristic species with sufficient constancy. Additionally, species *Centaurea carniolica* is

differential from other central European communities with *Molinia*.

Beside the mentioned species we name the following species as differential from other stands with *Molinia* (Tab. 2, relevés 1–8): *Sanguisorba officinalis*, *Gratiola officinalis*, *Cirsium rivulare*.

From similar association *Deschampsio-Plantagnetum altissimae* this association could

be told apart on the base of the *Molinia caerulea*, which is often dominant species here, but missing in the mentioned. Besides, this association could be delimited from the mentioned due to presence of the following species: *Serratula tinctoria*, *Carex nigra*, *Ranunculus flammula*, *Potentilla erecta*.

Syntaxonomic position and distribution in other countries: On the base of the comparison of the relevés we discovered the similarity of this association with the syntaxon *Deschampsio-Plantaginetum altissimae cirsietosum pannonicum* Ilijanić 1979, which thrives on the Cerkljiško jezero. Ilijanić (1979) had already pointed out the possibility of delineation of this subassociation and definition as specific association. Multivariate analyses revealed relatively higher similarity of the mentioned subassociation with *Plantagini altissimae-Molinietum caeruleae* than other units of the *Deschampsio-Plantaginetum altissimae* (Fig. 2). According to these findings we classified mentioned subassociation and our stands into association *Plantagini altissimae-Molinietum caeruleae*. However, stands from northern Italy are richer in fen species, so on the base of our data and additional research there is a possibility to describe a distinct subassociation in the future.

The only report about the thriving of this association outside Po plain is given by Zelnik and Čarni (2008a).

***Selino-Molinietum caeruleae* Kuhn 1937**

For this central association of the alliance *Molinion* many authors use the name *Molinietum caeruleae*, or *Molinietum medioeuropaeum* Oberdorfer 1957, which are not clearly defined. For this reason Ellmauer and Mucina (1993) suggest the name *Selino-Molinietum* Kuhn 1937 for such stands.

This is basophilic community that thrives in lowland and montane belt, mostly in less wet fen soils. Soils are almost equally wet throughout the whole year. Stands are mown in late summer or early autumn once a year or biennially. This community is a stage in succession of aquatic ecosystems to terrestrial leading from tall-sedge communities of the alliance *Magnocaricion elatae* Koch 1926, low-sedges from the alliance *Caricion davallianae* Klika 1934 to the community *Selino-*

Molinietum (Ellmauer and Mucina 1993). This association can also develop on the edge of bog or with degradation of fens.

First relevés from Slovenia that were classified into this association are from the vicinity of Slovenj Gradec and were published by Kaligarič (1997). Our relevés from various sites were classified into this association, which is in accordance with its central position and wide distribution (Tab. 3, relevés 22–37).

Characteristic species and plant species composition: This is a central community of the alliance *Molinion* that reflects in high constancy of characteristic species of this alliance.

In accordance with other authors (Ellmauer and Mucina 1993, Kaligarič 1997), we pointed out the following species as characteristic: *Selinum carvifolia*, *Laserpitium prutenicum*.

Syntaxonomic position and distribution in other countries: Since this is a central association of the alliance it similarity to the other associations is relatively high. Community was described in southern Germany by Kuhn (1937), but many authors classified more or less similar stands to macro-association *Molinietum caeruleae*, or *Molinietum medioeuropaeum*, that prevented a review. There is confusion in literature, since some authors classify different associations or their parts into *Selino-Molinietum* (Pott 1995). Even in the latest publications (Burkart et al. 2004, Havlová 2006, Janišová et al. 2007) this vegetation is classified as *Molinietum* Koch 1926.

The reasons for this is the difficulty of classification of the stands with *Molinia caerulea*, the lack of knowledge of the ecological conditions of these sites and the absence of multivariate analyses that would enable comparisons of plant species composition with relevés of other associations.

Another reason is the abandonment of mowing of the meadows, where stands with *Molinia caerulea* thrive that leads to the total dominance of this species, while others e.g. characteristic species of many associations disappear from the stands and make the suitable classification impossible. The consequence is the classification of such stands to the most intermediate association *Selino-Molinietum*.

Distribution of this association is documented in Germany (Kuhn 1937, Pott 1995), Austria (Balátová-Tuláčková and Hübl 1985a,

Ellmauer and Mucina 1993) and Italy (Sburlino et al. 1995).

***Carici davallianae-Molinietum caeruleae* Špániková 1978**

This community that represents a transition between wet meadows and fens is dominated by taxon *Molinia caerulea* ssp. *caerulea* and is often adjacent to the stands of *Caricetum davallianae* Dutoit 1924 (Špániková 1978), but its floristic composition is still richer in meadow species, which also dominate the stands.

These stands are often found in helocrenic springs that are surrounded by mesic communities. Soils are loamy and often with high share of organic matter. Soils are slightly acid to neutral, however, pH values and humidity are higher than in *Selino-Molinietum*. This association thrives in permanently wet sites rich in Ca^{2+} . These conditions reflect in higher share of the fen species. Since the soils are rarely dry enough, mowing with tractors is barely possible in these meadows that was evident in the field. With the lowering of water level the vegetation turns to the association *Selino-Molinietum*.

In all studied sites the influence of base-rich groundwater was obvious. Moreover, this water drains the limestone and/or dolomite and supplies these sites with high amounts of Ca^{2+} and Mg^{2+} . These sites are never on plane, but on slight slopes (3–10°). Stands of this association were recorded in Alpine, Pre-Alpine, Dinaric and Pre-Dinaric phytogeographic regions of Slovenia, on the following locations: Dolič, Sopota, Tatinec, Nemška vas.

Characteristic species and plant species composition: On the base of the comparison of our stands (Tab. 3, relevés 38–59) with stands of other associations, we defined (in accordance with Dierschke 1994) the following species as differential: *Carex davalliana*, *C. hostiana*, *Epipactis palustris*, *Koeleria pyramidata*, *Eriophorum latifolium*. Mentioned species are basophilic and except *Koeleria pyramidata* are all fen species. They mostly match with the differential species of the subassociation *Selino-Molinietum caricetosum davallianae* Balátová-Tuláčková & Hübl 1985 (*Carex davalliana*, *C. flava*, *Eriophorum latifolium*, *Parnassia palustris*), that was described in

eastern limestone Alps by Balátová-Tuláčková and Hübl (1985a). In the same publication these authors defined the same combination of the species (*Carex davalliana*, *Eriophorum latifolium*, *Parnassia palustris*) as differential for the subassociation *Molinietum caeruleae caricetosum davallianae* Görs 1951.

Syntaxonomic position and distribution in other countries: Unclear classification of this basophilic vegetation in Slovenia was firstly pointed out by Kaligarič (1997). Authors (e.g. Seliškar 1986, Leskovar 1996) have classified such stands with stands of different other associations (e.g. *Selino-Molinietum*, *Plantagini altissimae-Molinietum caeruleae*) into same syntaxon *Molinietum caeruleae* s.l. Figure 1 presents clear delimitation of these stands from relevés of other associations.

Studied association is similar to *Succiso-Molinietum caeruleae* (Kovacs 1962) Soó 1969 that thrives in Pannonian region, namely in Austria (Ellmauer and Mucina 1993) and Hungary (Borhidi 2003). In case of increasing moisture of those sites Wagner (1950) defined its transition to community *Schoenetum nigricantis* Koch 1926. In our case increasing moisture of the sites led to the fen community *Caricetum davallianae* Dutoit 1924.

Our relevés are very similar to the relevés published by Balátová-Tuláčková and Hübl (1985a) that are recorded in the Lower-Austrian limestone Alps, where the bedrock is actually the same as in our cases. Mentioned authors classified those stands into *Selino-Molinietum caricetosum davallianae* Balátová-Tuláčková & Hübl 1985 and *Molinietum caeruleae caricetosum davallianae* Görs 1951. Our relevés are also similar to the relevés from northern Italy (Lombardy) published by Sburlino et al. (1995: Tab. 2 / 1–9).

According to the mentioned facts and similarities we can conclude that this basophilic community is distributed over Slovenia and in other countries that reach into the southern and/or northern belt of calcareous Alps, Carpathians and NW Dinaric mountains.

***Junco-Molinietum caeruleae* Preising 1951 ex Klapp 1954**

Soils in this community are of loamy texture and could be gleysols (Balátová-Tuláčková and

Hübl, 1985b) and/or peat-soils. These sites are rarely fertilized and mown only once a year (Ellmauer and Mucina 1993). Sites are mostly on intermittently wet riverine soils or slopes with helocrenic springs (hanging mires). This association is common in areas with non-carboniferous bedrock and/or in wet places with thick layer of accumulated organic matter (peat).

In Slovenia this association is most common in Ljubljana moor, where it was documented by Seliškar (1986). Stands of this association were recorded on the following localities (Tab. 2, relevés 9–21): Nemška vas, Log pri Mokronogu, Selo pri Bledu. Soils under the stands on the mentioned localities are influenced by the base-poor water that drains non-calcareous sediments and/or are in depressions where rainwater is stagnating for weeks.

Characteristic species and plant species composition: Association is poorly floristically defined. Characteristic species of the order *Molinietalia Koch 1926* as well as of the alliance *Molinion* are relatively rare. Beside the mentioned characters, numerous species characteristic for the classes *Scheuchzerio-Caricetea fuscae* R.Tx. 1937 and *Calluno-Ulicetea* that indicate nutrient-poor acidic soils, were found in these stands.

Preising (1951), Ellmauer and Mucina (1993) defined species *Juncus conglomeratus* and *J. effusus* as differential from other associations.

Syntaxonomic position and distribution in other countries: After Ellmauer and Mucina (1993) this community is transitional towards following syntaxa: *Calthion*, *Caricion fuscae* (*Scheuchzerio-Caricetea fuscae*) and *Violion caninae* (*Calluno-Ulicetea*).

Such stands are found in Austria on silicate bedrock on the altitudes between 525 and 660 m a. s. l. (Balátová-Tuláčková and Hübl 1985b). Association thrives also in Hungary (Borhidi 1996), what is no longer evident in later publications (Borhidi 2003), since the name *Nardo-Molinietum hungaricae* is used for this type of vegetation. Association is also found in Czech Republic (Blažková 1973, Havlová 2006) and in Germany (Pott 1995), although in later publications (Burkart et al. 2004) these stands are classified to community *Juncus conglomeratus-Succisa pratensis*.

Division to lower syntaxa: Balátová-Tuláčková and Hübl (1985b) classified relevés from Austria

into subassociations *scirpetosum sylvaticae* Balátová-Tuláčková & Hübl 1985 and *typicum* Preising 1951.

Junco-Molinietum caeruleae typicum Preising 1951: Five our relevés, without differential species, were classified into typical subassociation (Tab. 2, relevés 17–21). Prevailing species in these stands are species of the order *Molinietalia* and class *Molinio-Arrhenatheretea*.

We defined new subassociation *succiselle-tosum inflexae* due to dominance of the species *Succisella inflexa* (Tab. 2, relevés 9–16; *holotipus*: Tab. 2 / relevé 13).

Junco-Molinietum caeruleae succiselle-tosum inflexae subass. nova hoc loco: On the bottoms of more distinctive depressions (> 0,2 m), beside the species *Molinia caerulea*, *Succisella inflexa*, that is characteristic species of the alliance *Deschampsion* Horvatić 1930, is very abundant. In such depressions soils are under influence of stagnating base-poor rainwater that makes the ecological conditions similar to the ones where communities of the alliance *Deschampsion* are found. Main difference in floristic composition is in presence and even dominance of the species *Molinia caerulea*.

Because of the mentioned conditions lower herb layer is dominated by species *Succisella inflexa* and *Carex panicea*, while upper is dominated by *Molinia caerulea*. Other species only exceptionally occur with higher cover values, their number is much lower than in other communities with *Molinia caerulea*. From other classes marsh species of the class *Phragmito-Magnocaricetea Klika 1941* can be found in these stands.

Such stands were recorded in the area of Alpine-Dinaric mountain barrier where the precipitation amount is the highest in Slovenia. These localities were: Nemška vas near Ribnica, Selo pri Bledu.

These stands thrive in sites that are wetter than sites of other communities like *Junco-Molinietum caeruleae typicum*, *Plantagini altissimae-Molinietum*, what reflects in plant species composition (Fig. 1). Further increasing of soil moisture on lower sites facilitates species of the classes *Phragmito-Magnocaricetea* and *Scheuchzerio-Caricetea fuscae* that become dominant.

Conclusions

Vegetation of wet meadows in the research area is very diverse. Our relevés with taxon *Molinia caerulea* subsp. *caerulea* were classified into alliance *Molinion* and further into four plant associations: *Plantagini altissimae-Molinietum caeruleae* Marchiori & Sbrulino 1982, *Carici davallianae-Molinietum caeruleae* Špáníková 1978, *Selino-Molinietum caeruleae* Kuhn 1937, *Junco-Molinietum caeruleae* Preising 1951. For the first two associations the relevés from Slovenia are published for the first time in analytical table in this paper. Beside the mentioned four associations another two vegetation types with dominant or co-dominant *Molinia caerulea* that are transitional to fens are found in Slovenia, namely *Schoeno nigricantis-Molinietum caeruleae* Martinčič 1991 and *Schoeno ferruginei-Molinietum caeruleae* Martinčič 2001. Since they occur on the margins of the fens which distribution is very limited (*Schoenetum nigricantis* Koch 1926, *Schoenetum ferruginei* Du Rietz 1925) only, they are not widely distributed and are not studied in this paper.

The association *Plantagini altissimae-Molinietum caeruleae* Marchiori & Sbrulino 1982 is found in the western part of studied area, where the climate is most humid and this is the main ecological difference with communities of the alliance *Deschampsion*, which thrive in the areas with more arid climate. This association is found also in northern Italy (Sbrulino et al. 1995).

The association *Selino-Molinietum caeruleae* Kuhn 1937 is the central association of the alliance *Molinion* and corresponds to the community *Molinietum caeruleae* Koch 1926 (Ellmauer and Mucina 1993, Zelnik 2005b), which is not efficiently defined. This community is found all over central Europe.

The association *Carici davallianae-Molinietum caeruleae* Špáníková 1978 is transitional to fen vegetation, but its floristic composition is still much richer in meadow species, which also dominate the stands. This association is found in central and north Slovenia (Zelnik 2005b).

Apart from the other three associations which are more or less basophilic, the association *Junco-Molinietum caeruleae* is acidophilic and is found in depressions with stagnating rainwater or on

peat-soils. This association is found in central, southeast and east Slovenia (Zelnik 2005a,b).

Most species-rich plant communities thrive in sites without any outstanding parameter that would have a dominating influence on the conditions. It is crucial that soils are nutrient-poor and flooded/waterlogged for short periods only.

Slovenia is in conjunction of Alpine, Mediterranean, Dinaric and Pannonian regions that reflects in diversity of wet meadow plant communities. We found plant communities that were described in Germany, Italy and Slovakia, and are distributed also in Austria, Hungary, Croatia, Czech Republic and Poland.

Povzetek

Mokrotni travniki so bili v zadnjem desetletju v Evropi pogosto predmet preučevanj, predvsem zaradi vedno večje ogroženosti njihove biodiverzitet, marsikje pa so ti ekosistemi že uničeni. Mokrotne travnike iz zveze *Molinion* Koch 1926 najdemo na tleh, ki so revna s hranili in so stalno ali občasno mokra. Za ohranjanje teh oligotrofnih ekosistemov je potrebno gospodarjenje, ki ne sme biti preveč ali premalo intenzivno.

Vegetacijo mokrotnih travnikov so v Sloveniji preučevali: Horvatić (1939), Ilijanić (1979), Seliškar (1986), Martinčič (1991, 2001), Leskovar (1996), Kaligarič (1997). Rezultati teh raziskav v zadnjem desetletju pa so objavljeni v: Zelnik (2005a), Zelnik in Čarni (2008a,b).

V Sloveniji je struktura rastlinskih združb mokrotnih travnikov podrobneje raziskana in objavljena predvsem na območjih kot je Cerkniško jezero, Ljubljansko barje, Bloke in Krška kotlina, medtem ko je v ostalih območjih strokovni javnosti nepoznana. Cilj prispevka je predstavitev značilnosti, floristične sestave, vrstne pestrosti in razširjenosti rastlinskih združb mokrotnih travnikov z *Molinia caerulea* ssp. *caerulea* v Sloveniji. Vegetacijo smo popisali po standardni srednjeevropski metodi. Vegetacijske tipe smo uvrstili v sintaksonomski sistem s pomočjo multivariatnih analiz. Določili in analizirali smo štiri asociacije iz zveze *Molinion*: *Plantagini altissimae-Molinietum caeruleae* Marchiori & Sbrulino 1982, *Selino-Molinietum caeruleae* Kuhn 1937, *Carici davallianae-Molinietum caeruleae*

Špániková 1978 in *Junco-Molinietum caeruleae* Preising 1951 ex Klapp 1954.

Plantagini altissimae-Molinietum caeruleae Marchiori & S Burlino 1982: Ta asociacija je bila opisana v vzhodnih predelih Padske nižine, kjer uspeva na povirnih mestih. Sestoje, ki smo jih uvrstili v to asociacijo smo popisali v dolini reke Nanoščiće. Uspevajo v večjih ulekninah, ki pa ne ležijo neposredno ob Nanoščici temveč ob njenih pritokih, ki imajo prispevna območja na pretežno nekarbonatnih kamninah.

V naših popisih (Tab. 2, popisi 1–8), se poleg značilnice *Plantago altissima* kot razlikovalnice od ostalih sestojev s stožko pojavljajo naslednje vrste: *Sanguisorba officinalis*, *Gratiola officinalis*, *Centaurea carniolica*, *Cirsium rivulare*. Od podobne združbe *Deschampsio-Plantaginetum altissimae* se ta asociacija bistveno loči po vrsti *Molinia caerulea*, ki je tukaj pogosto dominantna vrsta in po naslednjih vrstah: *Serratula tinctoria*, *Carex nigra*, *Ranunculus flammula*, *Potentilla erecta*.

Selino-Molinietum caeruleae Kuhn 1937: Za to osrednjo združbo zveze *Molinion* mnogi avtorji uporabljajo ime *Molinietum caeruleae*, oziroma *Molinietum medioeuropaeum* Oberdorfer 1957, ki pa sta premalo natančno definirani. Zato Ellmauer & Mucina (1993) za tovrstne sestoje predlagata uporabo imena *Selino-Molinietum* Kuhn 1937. To je bazifilna združba, ki uspeva v nižinskem in montanskem pasu, večinoma na manj vlažnih tleh. Tla so preko celega leta enakomerno vlažna. Prve popise iz Slovenije, ki so klasificirani v to asociacijo, je objavil Kaligarič (1997).

Kot značilnice smo izpostavili naslednji vrsti: *Selinum carvifolia*, *Laserpitium prutenicum*.

Ker je to osrednja asociacija zveze *Molinion*, je zaradi svoje relativne zmernosti tudi najbolj podobna vsem ostalim združbam iz te zveze. Klasifikacija teh sestojev je pogosto težavna zaradi nepoznavanja rastiščnih razmer in opuščanja košnje teh površin, zaradi česar modra stožka popolnoma prevlada, ostale vrste med drugim tudi značilnice, pa izginjajo iz sestojev.

Carici davallianae-Molinietum caeruleae Špániková 1978: V tej združbi, ki predstavlja prehod med mokrotnimi travniki in nizkimi barji in je pogosto v stiku z asociacijo *Caricetum davallianae*, prevladuje vrsta *Molinia caerulea*. Sestoje te združbe vedno najdemo na povirnih mestih.

Tla so ilovnata in pogosto z visokim deležem organske snovi (šotnata), reakcija tal je rahlo kislja do nevtralna, višja kot v asociaciji *Selino-Molinietum*. Na vseh rastiščih je bilo očitno, da gre za vpliv z bazami bogate talne vode, oziroma mezeče povirne vode. Ta rastišča so vedno na blagih pobočjih (3–10°).

Na osnovi naših popisov smo kot dobre razlikovalne vrste, oziroma značilnice definirali naslednje bazifilne vrste: *Carex davalliana*, *C. hostiana*, *Epipactis palustris*, *Koeleria pyramidata*, *Eriophorum latifolium*.

V preteklosti so tovrstne popise različno klasificirali in jih združevali v sintakson *Molinietum caeruleae* s.l., s popisi drugih sintaksonov z modro stožko. Na sliki 1 vidimo, da se popisi obravnavane asociacije jasno razlikujejo od ostalih. Zelo podobni našim popisom, so sestoji, ki jih navajata Balátová-Tuláčková & Hübl (1985a) z avstrijskih apneniških Alp in sestoji iz severne Italije (S Burlino in sod. 1995).

Junco-Molinietum caeruleae Preising 1951 ex Klapp 1954: Tla v tej združbi so pogosto oglejena, oziroma so šotnata. Ta asociacija je pogosta v območjih, kjer prevladuje nekarbonatna podlaga, oziroma na rastiščih, kjer je zaradi upočasnjene razgradnje nastala debela plast organskih snovi. V Sloveniji je ta asociacija pogosta predvsem na Ljubljanskem barju. Sestoje iz te asociacije smo popisali na lokacijah Nemska vas, Log pri Mokronogu in Selo pri Bledu, kjer so tla pod vplivom z bazami revne talne vode, oziroma zastajajoče deževnice.

Združba je floristično slabo definirana. Kot razlikovalnice od ostalih stožkovij navajamo vrsti *Juncus conglomeratus* in *J. effusus*.

V tipično subasociacijo smo uvrstili pet popisov (Tabela 2, popisi 17–21), v katerih nismo našli diferencialnih vrst. Zaradi dominance vrste *Succisella inflexa* v kotanjah, smo definirali novo subasociacijo *succiselleetosum inflexae*.

Junco-Molinietum caeruleae succiselleetosum inflexae subass. nova hoc loco: Tabela 2, popisi 9–16; *holotip*: tabela 2 / popis 13. V izrazitejših ulekninah dlje časa zastaja deževnica, zato v teh sestojih z visoko pokrovostjo uspeva tudi vrsta *Succisella inflexa*, ki je značilnica zveze *Deschampsion*. Bistvena razlika v floristični sestavi je v uspevanju in dominanci vrste *Molinia caerulea*. Zaradi omenjenih ekstremnih razmer v spodnjem

zeliščnem sloju prevladujeta vrsti *Succisella inflexa* in *Carex panicea*, v zgornjem pa dominira vrsta *Molinia caerulea*. Poleg teh, se ostale vrste le izjemoma pojavljajo z višjimi pokrovnostmi, število vrst pa je na splošno mnogo manjše kot v ostalih stožkovjih.

Tovrstne sestoje smo našli na območju alpsko-dinarske pregrade, kjer je količina padavin največja v Sloveniji, in sicer na lokalitetah Nemška vas v Ribniški dolini in Selo pri Bledu.

Slovenija je na stičišču panonske, dinarske, alpske in sredozemske regije, kar se odraža tudi v pestrosti travniške vegetacije. V Sloveniji smo

tako našli asociacije, ki so bile opisane v Nemčiji, v Italiji in na Slovaškem, uspevajo pa tudi na Hrvaškem, na Madžarskem, v Avstriji, na Češkem, na Poljskem.

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Appendix:

List of the relevé localities (from Tables 2 and 3):

Plantagini altissimae-Molinietum:

- 1: 0251/1 Mrzlek; 2: 0251/1 Mrzlek; 3: 0251/1 Mrzlek; 4: 0251/1 Zagon; 5: 0251/1 Mrzlek; 6: 0251/1 Mrzlek; 7: 0251/1 Mrzlek; 8: 0251/1 Zagon.

Junco-Molinietum caeruleae:

- 9: 0254/3 Nemška vas; 10: 0254/3 Nemška vas; 11: 0254/3 Nemška vas; 12: 0254/3 Nemška vas; 13: 9650/4 Selo pri Bledu; 14: 9650/4 Selo pri Bledu; 15: 9650/4 Selo pri Bledu; 16: 0254/3 Nemška vas;
17: 0254/3 Nemška vas; 18: 0254/3 Nemška vas; 19: 0254/3 Nemška vas; 20: 0056/4 Log pri Mokronogu; 21: 0056/4 Log pri Mokronogu.

Selino-Molinietum caeruleae:

- 22: 0054/3 Radensko polje; 23: 0054/3 Radensko polje; 24: 0254/3 Nemška vas; 25: 0054/3 Radensko polje; 26: 9650/2 Podhom; 27: 9955/2 Sopota; 28: 0054/3 Radensko polje; 29: Dobje; 30: 9556/1 Radoše; 31: 9650/2 Podhom; 32: 0054/3 Radensko polje; 33: 9752/1 Tatinec; 34: 0054/3 Radensko polje; 35: 0054/3 Radensko polje; 36: 0054/3 Radensko polje; 37: 0054/3 Radensko polje.

Carici davallianae-Molinietum caeruleae:

- 38: 0054/3 Radensko polje; 39: 9557/3 Dolič; 40: 9955/2 Sopota; 41: 9557/3 Dolič; 42: 9557/3 Dolič; 43: 9557/3 Dolič; 44: 9955/2 Sopota; 45: 9955/2 Sopota; 46: 9955/2 Sopota; 47: 9955/2 Sopota; 48: 9955/2 Sopota; 49: 9955/2 Sopota; 50: 9955/2 Sopota; 51: 9557/3 Dolič; 52: 0056/3 Dol pri Trebnjem; 53: 9752/1 Tatinec; 54: 9752/1 Tatinec; 55: 9752/1 Tatinec; 56: 9752/1 Tatinec; 57: 9752/1 Tatinec; 58: 9752/1 Tatinec; 59: 9752/1 Tatinec.

Community number	1	2	3	4	5
Number of relevés	8	8	5	17	21
Number of plant taxa	47	23	37	39	33
<i>Plantagin altissimae-Molinietum caeruleae</i>					
<i>Sanguisorba officinalis</i>	100	.	.	.	.
<i>Plantago altissima</i>	100	38	.	6	.
<i>Gratiola officinalis</i>	100	62	20	29	.
<i>Centaurea carnolica</i>	100	.	.	18	19
<i>Cirsium rivulare</i>	75	12	40	6	5
<i>Serratula tinctoria</i>	75	12	.	12	5
<i>Ranunculus flammula</i>	62	25	20	6	.
<i>Carex nigra</i>	50	.	20	.	.
<i>Junco-Molinietum caeruleae succiselletosum inflexae</i> subass. nova					
<i>Succisella inflexa</i>	25	100	.	29	.
<i>Junco-Molinietum caeruleae typicum</i>					
<i>Juncus conglomeratus</i>	100	50	60	35	5
<i>Juncus effusus</i>	25	.	60	6	.
<i>Selino-Molinietum caeruleae</i>					
<i>Selinum carvifolia</i>	75	.	20	76	.
<i>Laserpitium prutenicum</i>	.	.	.	71	.
<i>Carici davallianae-Molinietum caeruleae</i>					
<i>Carex davalliana</i>	.	.	.	12	95
<i>Carex hostiana</i>	12	50	20	71	90
<i>Epipactis palustris</i>	.	12	.	6	90
<i>Koeleria pyramidata</i>	.	.	.	24	76
<i>Eriophorum latifolium</i>	.	.	.	6	52
Molinia					
<i>Molinia caerulea</i> subsp. <i>caerulea</i>	100	100	100	100	100
<i>Succisa pratensis</i>	75	12	60	94	95
<i>Gentiana pneumonanthe</i>	38	62	60	65	.
<i>Galium boreale</i>	50	.	20	59	24
<i>Carex distans</i>	12	25	.	12	24
<i>Molinia arundinacea</i>	.	.	40	12	10
<i>Inula salicina</i>	.	38	.	.	5
<i>Iris sibirica</i>	12	.	.	18	.
<i>Gladiolus palustris</i>	.	.	.	6	10
<i>Carex tomentosa</i>	.	.	.	18	.
<i>Gentiana asclepiadea</i>	.	.	.	6	5
<i>Polygala amarella</i>	.	.	.	.	10
<i>Ophioglossum vulgatum</i>	12	.	.	.	.
<i>Vicia tetrasperma</i>	.	.	20	.	.
Molinietalia					
<i>Filipendula ulmaria</i>	88	88	100	53	19
<i>Lythrum salicaria</i>	62	100	100	29	33
<i>Valeriana dioica</i>	75	38	60	41	67
<i>Lysimachia vulgaris</i>	38	100	80	35	24
<i>Equisetum palustre</i>	38	88	40	18	62
<i>Juncus acutiflorus</i>	88	50	60	18	.
<i>Betonica officinalis</i>	88	.	40	71	48
<i>Angelica sylvestris</i>	38	.	20	35	57
<i>Deschampsia cespitosa</i>	38	.	40	18	5
<i>Genista tinctoria</i>	12	.	20	53	29
<i>Lychnis flos-cuculi</i>	88	.	60	6	.
<i>Linum catharticum</i>	25	.	.	29	33
<i>Thalictrum lucidum</i>	.	88	20	6	.
<i>Myosotis scorpioides</i>	88	12	.	12	.
<i>Gymnadenia conopsea</i>	.	.	.	6	52
<i>Lotus pedunculatus</i>	.	12	.	12	24
<i>Senecio aquaticus</i> agg.	50	38	.	.	.
<i>Cirsium palustre</i>	.	.	.	.	29
<i>Cirsium oleraceum</i>	.	.	.	29	33
<i>Geum rivale</i>	.	.	.	6	24
<i>Cardamine pratensis</i> agg.	12	.	20	12	.
<i>Galium uliginosum</i>	.	.	.	6	14
<i>Peucedanum coriaceum</i>	38	.	.	.	.
<i>Crepis paludosa</i>	25	.	.	6	.
<i>Dactylorhiza maculata</i>	25	.	.	6	.
<i>Colchicum autumnale</i>	12	.	.	12	.
<i>Veratrum album</i>	.	.	.	12	5
<i>Hypericum tetrapterum</i>	.	.	20	.	5
<i>Scirpus sylvaticus</i>	.	.	.	6	5
<i>Allium angulosum</i>	.	.	.	6	.
<i>Caltha palustris</i>	.	.	.	6	.

Table 1: Shortened percentage synoptic table of the studied wet meadows plant communities with *Molinia caerulea*: 1 – *Plantagin altissimae-Molinietum caeruleae*, 2 – *Junco-Molinietum caeruleae succiselletosum inflexae* 3 – *Junco-Molinietum caeruleae typicum*, 4 – *Selino-Molinietum caeruleae*, 5 – *Carici davallianae-Molinietum caeruleae*.
Tabela 1: Skrajšana sinoptična tabela (prisotnost v %) preučevanih rastlinskih združb mokrotnih travnikov z vrsto *Molinia caerulea*:

relevé number	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59		
relevé code	106	107	179	199	199	23	111	7	14	198	112	113	72	96	97	98	99	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101		
year	03	03	04	03	04	03	03	04	04	03	03	04	03	03	03	03	03	03	04	04	04	04	03	03	03	03	03	03	03	03	03	03	03	03	03	03	03	03	03	03
month	8	8	8	7	8	7	8	7	8	7	7	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	
day	18	18	12	2	20	21	2	25	5	20	2	2	30	12	12	13	13	5	21	5	5	21	21	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	
plot size (m2)	18	24	24	24	20	18	20	15	18	20	20	24	24	20	20	20	18	16	25	20	20	24	16	18	20	16	16	20	20	20	24	24	20	24	20	24	20	20	20	
altitude (m)	32	32	42	46	37	50	38	61	29	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
number of taxa	42	37	42	46	37	50	38	61	29	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	
characteristic and differential taxa of the association <i>Plantagini altissimae-Molinietum caeruleae</i>																																								
<i>Plantago altissima</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Gratiola officinalis</i>	3	4	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Centaurea carniolica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cirsium rivulare</i>	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Serratula tinctoria</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Ranunculus flammula</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
characteristic species of the association <i>Junco-Molinietum caeruleae</i>																																								
<i>Juncus conglomeratus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Juncus effusus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
differential species of the subassociation <i>succiselletosum inflexae</i> subass. nova																																								
<i>Succisella inflexa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
characteristic species of the association <i>Selinio-Molinietum caeruleae</i>																																								
<i>Selinum carvifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Laserepitium prutenicum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
characteristic and differential species of the association <i>Carici davallianae-Molinietum caeruleae</i>																																								
<i>Carex davalliana</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Carex hostiana</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Epipactis palustris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Koeleria pyramidata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Eriophorum latifolium</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Molinia																																								
<i>Molinia caerulea</i>	4	5	4	3	4	5	4	5	4	4	5	5	4	4	4	4	4	4	4	4	4	4	5	4	5	5	4	4	5	4	4	4	4	4	5	5	4	4		
<i>Succisa pratensis</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
<i>Gentiana pneumonanthe</i>
<i>Galium boreale</i>
<i>Carex distans</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Molinia arundinacea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Inula salicina</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Iris sibirica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Gladiolus palustris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Carex tomentosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Gentiana asclepiadea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygala amarella</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Molinietalia																																								
<i>Valeriana diaca</i>	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
<i>Filipendula ulmaria</i>
<i>Betonica officinalis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lythrum salicaria</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Equisetum palustre</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lysimachia vulgaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Angelica sylvestris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Genista tinctoria</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Linum catharticum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cirsium oleraceum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Gymnadenia conopsea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lychnis fls-cuculi</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Myosotis scorpioides</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Deschampsia cespitosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Thalictrum lucidum</i>	.	.	.																																					

