Successional changes of *Nardus stricta* communities in the Central Balkan Range (Bulgaria)

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Abstract. Main succession changes are traced down in the *Nardus stricta* communities from the Central Balkan Range (Bulgaria). The demutational phase covers a period of 2–3 decades. Vegetation dynamics processes are analysed in parallel, according to the method of Braun-Blanquet and the Dominant approach. Classification of the communities according to the two approaches is offered. The *Nardetum strictae* and *Bruckenthalio-Juniperetum sibiricae* associations represent two opposite points in the succession process. The spatial and the syntaxonomic correlation between the vegetation units is analysed, regarding the two phytocoenological schools.

Key words: Braun-Blanquet approach, classification, Dominant approach, vegetation dynamics

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Introduction

Succession is usually defined as a temporary aspect of the community structure comprising non-seasonal, directed and cumulative changes in vegetation during the time that set in through emergence or disappearance of species, or through changes in the quantitative correlations between the species (Braun-Blanquet 1965; Gittins 1981; Mueller-Dombois 1981; Begon & al. 1986). According to Moravec (1969), succession does not represent the development of one and the same phytocoenosis, but is a gradual, uniform, directed, and irreversible replacement of one phytocoenosis with another on the same place. Schmithüsen (1961) has similar understanding of that process. Replacement of one phytocoenosis with another is also considered as basic content of the successional changes in the Russian phytocoenological school: succession is a process consisting of irreversible and directed changes in the phytocoenoses leading to their replacement with other phytocoenoses (Shennikov 1964; Rabotnov 1978).

Vegetation changes in the succession process depend on time and could be divided into stages. A clearly distinguishable step in the succession process is called *stage*. This is the smallest and indivisible concrete development unit and each stage could be defined floristically and ecologically (Braun-Blanquet 1965). Stages may differ only slightly, in dominance or coverage of some species, but they could also register a great qualitative difference, such as a change in the community floristic composition (Knapp 1974; Bornkamm 1981).

The substitution of one community with another takes place via gradual penetration of the species from the next stage into the existing one, accompanied with gradual disappearance of some species, characteristic for the previous stage (Moravec 1969). When a stage is identical to a syntaxonomically defined community type, this syntaxonomic unit could be used to name the stage (Knapp 1974).

Juniperus sibirica Burgsd., dominated communities in the Balkan Range, were burned and cut down in the past to enlarge the pastures (Kochev 1967; Mišić & al. 1978). Kochev (1967) mentioned the wide distribution of *Agrostis capillaris* L. and *Nardus stricta* L. communities as a result of burning down siberian juniper and of the secondary expansion of the mat-grass communities after intensive grazing and trampling. Similar processes have been observed in neighbouring Romania (Grigoriu & Alda 2004; Niculescu 2004). After deforestation the highly productive *Festuca rubra* L. and *A. capillaris* communities (at lower altitudes), and *F. nigrescens* Lam. communities (at higher altitudes) had developed. Subsequently, they were replaced by *N. stricta* dominated communities, under intensive grazing and on poor, acid soils.

Nardus stricta dominated communities are very stable and of long standing. Such phytocoenoses, which are not in their climax phase but for one or another reason remain unchanged for long periods of time, are called *permanent communities* (Schmithüsen 1961; Braun-Blanquet 1965; Lemée 1967) or *blocked successional stages* (Moravec 1969).

Today, grazing intensity in the Central Balkan Range is much decreased and in many localities the pastures are abandoned, owing to which intensive regenerative processes have been observed in the region. Regeneration of the natural vegetation in the same place, after a grave interruption, is secondary succession (Schmithüsen 1961; Odum 1971; Ricklefs 1976; Rabotnov 1978) and is called "demutation", "regenerative changes" or "progressive succession" (Schmithüsen 1961; Shennikov 1964; Bykov 1970; Rabotnov 1978).

Meshinev & al. (2000) analysed the succession processes in the high-mountain treeless zone of the Central Balkan Range following the Dominant Approach, and reported a transition from the *N. stricta* communities to the climax (subclimax?) vegetation consisting of *J. sibirica* dominated communities and a mosaic of subalpine herbaceous formations. Transition of the *N. stricta* communities to *Vaccinium myrtillus* L. and *J. sibirica* communities as a result of decreased grazing was reported also for Romania by Grigoriu & Alda (2004). Generally, the vegetation succession that is under way in the region bears to a great extent the stamp of the anthropogenic and zoogenic impact.

A review of the available literature has contributed to the impression that the researchers of the Braun-Blanquet school seldom engage in relation the successional processes to strictly syntaxonomic changes. Investigations into the primary and secondary succession emphasize chiefly on the qualitative and quantitative changes in the species composition with time, without indicating the changes in the syntaxonomic status of the communities. This circumstance has been probably enforced by the fact that the change of one syntaxon to another in the progress of succession defined by the Braun-Blanquet school requires a very long period of time, contrary to the Dominant approach, where a new syntaxon is reached after changes of the dominant species or of the dominant-subdominant species combination. Such changes could take place in a relatively short period of time.

In this study, the authors seek to show some directions of change of the mat-grass communities in the Central Balkan Range after grazing reduction, as well as to compare the scope of syntaxa defined by the two methodological approaches.

Material and methods

Relevé sampling has been made within the framework of the Central Balkan National Park management plan preparation project (Meshinev & al. 2000). For the purposes of the project, detailed data on the geographical, climatic and soil characteristics of the National Park were submitted (Popov & Meshinev 2000).

Initially, data were collected on the basis of dominance principle (Lavrenko 1959; Shennikov 1964; Sukachev 1964; Aleksandrova 1973). Each sample plot contains the complete species composition of the phytocoenosis. The size of the sample plot varies depending on the homogeneity of the vegetation cover (most frequently it was 100 m^2). The relevés were stored in the TURBOVEG data base (Hennekens & Schaminèe 2001).

Meshinev & al. (2000) classified the communities following the Dominant approach. In this study the same relevés are classified according to the Braun-Blanquet approach (Braun-Blanquet 1965; Westhoff & der Maarel 1973; Mueller-Dombois & Ellenberg 1974). For the purposes of classification according to the floristic school, the original quantitative estimates of the species were converted according to the combined 7-point scale for abundance and coverage (Braun-Blanquet 1965) following a method proposed by Meshinev & Apostolova (2002). The analyses were made with the help of the JUICE software package (Tichy 2002).

It is well known that both phytocoenological schools accept the discreet character of the vegetation cover, while the plant association is accepted as a basic syntaxonomic unit.

To reveal the succession trends and the relative continuum between the associations, Indirect Gradient Analysis (Orloci 1973) was used with the help of CANOCO software package (ter Braak & Šmilauer 2002). Two ordination methods are applied – Principal Component Analysis (PCA) and Detrended Correspondence Analysis (DCA) for summarizing the changes of species composition within analysed plots. The axes are ecologically interpreted. Square-root data transformation was used in both analyses.

The species nomenclature follows Kozhuharov (1992).

Results and discussion

The analysed 76 relevés were referred to the associations *Nardetum strictae* Greb. 1950 and *Bruckenthalio-Juniperetum sibiricae* Horvat 1938 emend. Zupančič 1992. Both associations are distributed in the subalpine belt, within the altitude range of 1480–2080 m.

The relevés are presented in Table 1. They are arranged in a descending order, according to the quantitative estimates of *N. stricta*, in order to illustrate the succession changes.

The *Nardetum strictae* association is secondary in origin, representing some highly degraded vegetation, submitted to the strongest possible anthropogenic impact. The *Bruckenthalio-Juniperetum sibiricae* association represents the climax vegetation in the subalpine belt of the region.

These associations correlate with 43 associations that belong to eight formations defined by the Dominant approach (Table 2). It is well known that plant associations in the Braun-Blanquet school have a greater volume than the associations according to the Dominant approach (Karamysheva 1967; Mirkin 1978), which explains the great difference in the number of correlating syntaxa.

The final degradation phase is determined by the quantitative share of *N. stricta* in the community structure over 75 %. It is observed in 11 of the analysed sample plots which relate to the *Nardus stricta* association according to the Dominant approach, and to *Nardetum strictae* association according to the Florisitic approach. The final stage of pasture digression is characterized by the lowest biological diversity (Fig. 3). With decrease of the anthropogenic impact, the presence of *N. stricta* in the communities begins to shrink, which conditions the changes in their floristic composition. Thus, with time, correlations among the species change. Gibson & Brown (1992) regard time as the major factor determining the species composition of the pastures after grazing abandonement. Demutation directed to the association *Bruckenthalio-Juniperetum sibiricae* is accompanied by an increase in abundance and coverage of *J. sibirica*, *Bruckenthalia spiculifolia* Rchb., *Rubus idaeus* L., *Vaccinium vitis-idaea* L., and *V. myrtillus* L. (Fig. 1). This marks the beginning of the demutational process.

The presence of shrub and partially of tree species (*Juniperus, Vaccinium, Picea)* in the mat-grass communities shows a trend towards regeneration and proves that *N. stricta* has moved into shrub and tree habitats.

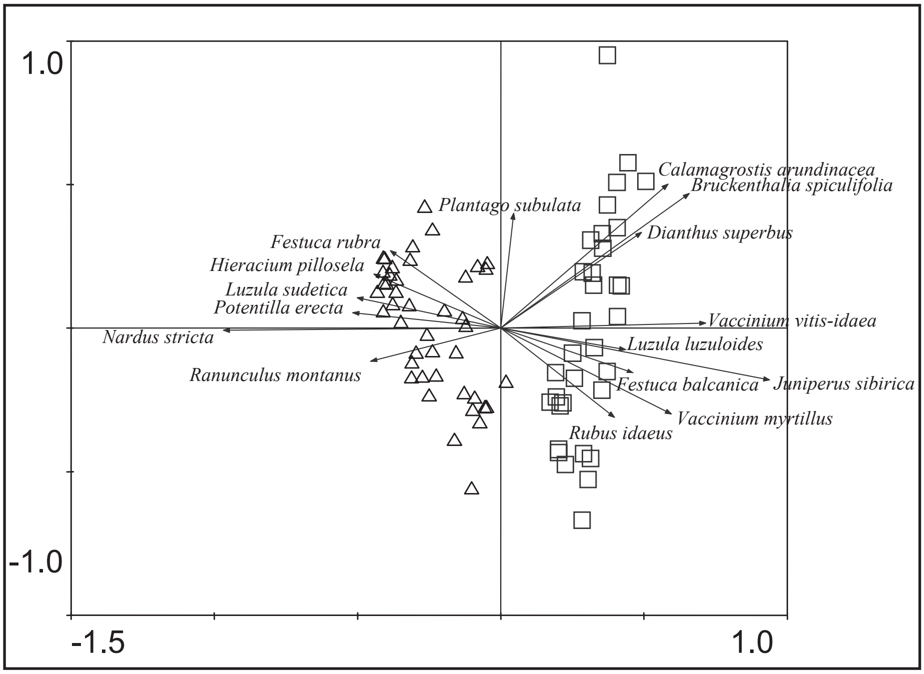

Fig. 1. PCA diagram of the 76 relevés.
Legend: △ – ass. *Nardetum strictae*; □ – ass. *Bruckenthalio-Juniperetum*

Ganchev & Kochev (1969) and Mišić & al. (1978) mentioned the transition of *N. stricta* communities into *A. capillaris* communities after the grazing discontinuance. They reported the replacement of *N. stricta* by larger gramineous plants [*Lerchenfeldia flexuosa* (L.) Schur., *Anthoxanthum odoratum* L., *Bellardiochloa violacea* (Bell.) Chiov., etc.] already in the first years after the stopping of grazing. Different species appear as subdominants depending on the particular environment, as for instance *B. violacea* occupies ridges and more eroded terrains while *A. capillaris* prevails in plane areas with well moistured and deep soils.

The phytocoenoses referred to the associations of *Nardus stricta,* and respectively to *Nardetum strictae*, are secondary in origin and that is why when the disturbances (grazing) stop they demutate towards the primary vegetation.

Dominant species in the opposite successional stages (*N. stricta, J. sibirica, V. vitis-idaea, B. spiculifolia*) are well separated in PCA diagram (Fig. 1). However, the relevés that belong to *Nardetum strictae* and *Bruckenthalio–Juniperetum sibiricae* associations are dispersed along Y – axis. Due to such dispersion, the relevés that are located at opposite ends of the successional gradient are closely distributed in ordination plane. Such result may mislead to the conclusion that floristic composition of these relevés are similar. PCA often produces undesirable "arch" or "horseshoe" effect (Gauch 1982; Karadžić & al. 1999). In such cases, communities and species that are located at opposite sides of an environmental gradients are closely distributed in ordination planes. In order to eliminate the curvilinear distortion of clearly recognized successional gradient, we perfomed detrended correspondence analysis (DCA).

Figure 2 shows the succession gradient of the communities which lies along the X-axis of the diagram. One can see that the gradient of changes clearly correlates with the gradient of *N. stricta* abundance. The set of relevés referred to the associations of *Nardetum strictae* and *Bruckenthalio-Juniperetium sibiricae* has a clearly expressed continuum. Within the framework of that continuum, the opposite processes of degradation and demutation take place. This is illustrated by the X-axis which could be viewed as coenocline of the process. The X-axis could be also viewed as the time of succession, i.e. the time gradient of succession. According to Whittaker & Woodwell (1973), the succession could be viewed as ecocline in time.

In the DCA diagram, the final degradation phase is positioned as far as possible from the climax vegetation on the first axis. In the two opposite ends of the gradient the associations of *N. stricta* are positioned, defined according to the Dominant approach, as a representative of the final phase of pasture digression, and of *J. sibirica*, as a representative of climax vege-

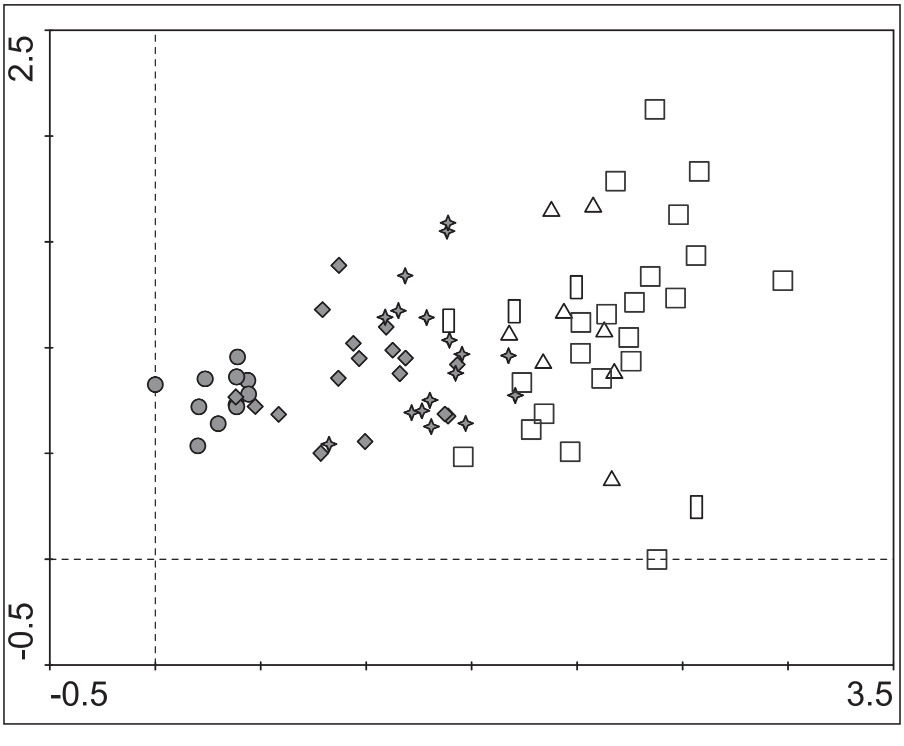

Fig. 2. DCA diagram of the 76 relevés.

Legend:

All black figures – ass. *Nardetum strictae*

All white figures – ass. *Bruckenthalio-Juniperetum*

Cover/abundance estimate of *N. stricta:*

● – 5

◆ – 4

✦ – 3

▯ – 2

△ – +

□ – without *N. stricta*

tation. The phytocoenoses subjected to different anthropogenic impact occupy an intermediate position. These are the samples where the vegetation is differently disturbed and the opposite processes of pasture digression and pasture demutation are in an intermediate stage (Tables 1, 2).

Figure 2 presents the strong unifying role of intensive grazing in relation to the general environmental conditions. It is obvious that at reduced grazing the abundance of *N. stricta* respectively decreases and the phytocoenoses disperse along the Y-axis. This results from the manifestation of the natural environmental conditions diversity, previously suppressed by intensive grazing. The Y-axis could be interpreted as an ecocline – gradient of the environmental factors.

Figure 3 points out the richest in species communities in which *N. stricta* has a cover/abundance estimate "2". This is an intermediate succession phase under a moderate anthropogenic impact. The moderate degree of disturbance, in this case the moderate grazing, favours the enhancement of biological diversity and this corresponds to the conception of intermediate disturbances (Connell 1978). Grazing often is the major factor regulating the species composition of the pastures (Miles 1981).

After a lasting for long grazing abandonement, the demutation process reaches its final point: formation of climax vegetation, which in the subalpine belt of the Balkan Range is represented by the *Bruckenthalio-Juniperetum sibiricae* asosciation. Unlike *Vaccinio–Juniperetum sibiricae* Mišić 1964 and *Piceo subalpine–Vaccinio–Juniperetum* Mišić & Popović 1954 associations described in Serbia, which are considered as secondary on the place of former coniferous forests dominated by *Picea abies* (Mišić & al. 1978; Kojić & al. 1998), *Bruckenthalio-Juniperetum sibiricae* is considered as the climax vegetation in the studied region. According to palynological data (Filipovitch & Petrova 1995; Filipovitch & al. 1997) the spruce forests have built a coniferous belt during Subboreal. Later on they have been replaced by the expansion of the beech and since that in the Bulgarian part of the Balkan Range there have not been established continuous coniferous belt. This fact undoubtedly leads to the conclusion that the *Juniperus sibirica* dominated communities in the studied region should be considered as climax vegetation but not as derived from spruce clearings.

The species that are of decisive importance for the replacement of one successional stage by another are called "destructive", while the species that build up the next stage are called "constructive" (Knapp 1974). During transition of the *Bruckenthalio-Juniperetum sibiricae* association into *Nardetum strictae* association, *N. stricta* appears as a constructive species, because it plays a decisive role for the development of the association *Nardetum strictae*. However, this species cannot be regarded as destructive, because in this case the destructive factors are the disturbances that have set in following human interference: overgrazing.

Owing to its high edification role, *J. sibirica* could be regarded as destructive because its development gradually destroys the conditions for existence the *Nardetum strictae* association. At the same time it could be considered as a constructive species for the establishment of the next stage: *Bruckenthalio-Juniperetum sibiricae*. In the process of demutation the territories of juniper expand in a natural way. The transition *Nardus stricta* → *Juniperus sibirica* is a natural process in the result of demutation, while the reverse transition *Juniperus sibirica* → *Nardus stricta* is an unnatural process resulting from digressions.

Figure 4 presents some basic syngenetic and spatial relationships between the syntaxa, defined ac-

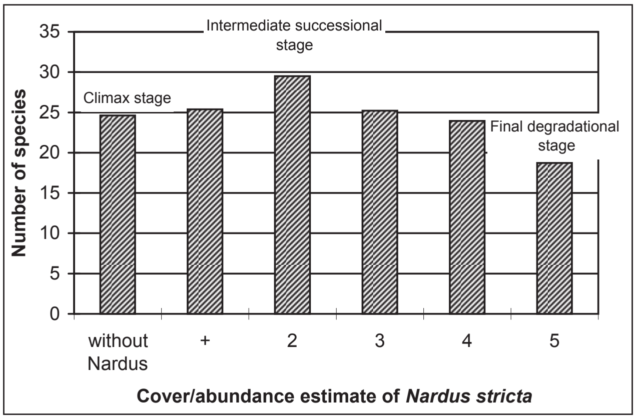

Fig. 3. Species diversity within the different successional stages.

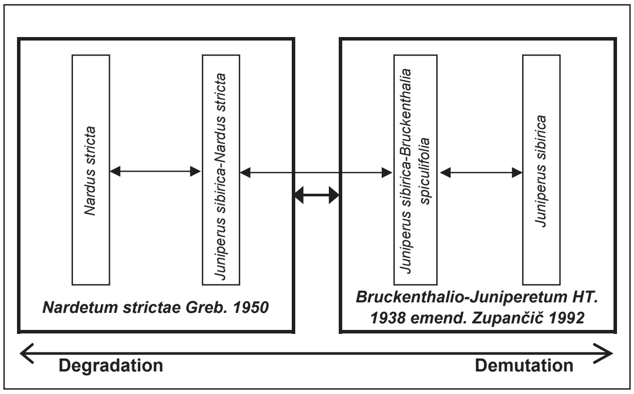

Fig. 4. The main spatial and successional interrelations between the associations.

Table 1. Associations *Nardetum strictae* Greb. 1950 and *Bruckenthalio-Juniperetum sibiricae* Horvat 1938 emend. Zupančič 1992 with corresponding syntaxa defined by Dominant approach.

Association	*Nardetum strictae*																																												*Bruckenthalio-Juniperetum sibiricae*																																	
Referent numbers with table 2	1	1	1	1	1	1	1	1	1	1	1	2	3	4	5	6	7	1	5	8	9	10	1	1	1	11	1	12	13	11	11	11	14	15	13	11	2	16	17	3	18	11	19	Constancy	20	21	22	23	24	25	26	27	28	29	30	31	32	27	33	34	35	36	27	21	21	21	36	26	37	36	38	39	23	40	41	42	43	Constancy
Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	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	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	
Altitude	1800	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1700	1950	1890	1850	1950	1700	1620	2000	2000	1600	1650	1520	1650	2000	1750	1900	1850	1750	1480	1850	2000	1800	1800	1700	1500	1700	1650	1550	1650	1750	1750	2080		1700	1600	1600	1750	1750	1800	1750	1500	1700	1750	1850	1550	1650	1750	1650	1600	1800	1650	1700	1700	1630	1650	1950	1700	1750	1700	1700	2000	1700	1700	1500	1875	1950	
Exposition		NW	NW	W	W	W	N	N	NW	W	NE	E	S	E		W		NW	EES	S	W	S	NW	E	NW	SE	SSE	S	W	E	EEN	W	S	SE	S	S	S	NE	E	SW	S	W	E		W	NWW	E	S	SE	E	W	NWW	NE	SSW	E	SE	SW	E	NE	N	SW	E	S	SE	E	W	S	S	N	W	E	N	SW	N	SSW	E	W	
Potentillo-Nardion																																																																														
Nardus stricta	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	V	2	2	2	2	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Thymus vandasii	.	.	.	.	.	1	.	1	.	.	+	+	+	+	.	+	+	+	.	+	.	.	+	.	.	+	+	+	+	+	.	.	+	+	+	.	+	+	1	+	.	+	+	III	.	2	+	+	1	+	.	+	.	+	.	1	.	+	.	+	+	.	1	+	+	+	+	.	1	+	.	.	+	.	+	.	.	IV
Hieracium hoppeanum	.	.	.	.	.	.	.	.	.	.	.	+	.	1	+	+	.	+	.	.	.	.	.	.	.	+	+	+	+	+	+	.	+	3	+	1	+	.	+	+	+	+	+	III	+	+	+	+	1	+	.	+	.	+	.	2	.	.	+	+	.	.	.	+	+	+	.	1	+	.	.	.	+	.	+	+	.	III
Poa media	.	1	.	+	.	1	+	1	+	+	+	.	.	.	+	+	.	+	.	+	.	2	.	.	+	1	1	3	1	.	.	.	+	.	.	+	+	+	.	+	1	+	.	III	.	+	.	.	.	.	.	.	+	+	3	.	+	1	.	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	II
Potentilla erecta	+	+	+	+	1	1	.	.	+	.	+	+	.	.	+	.	.	+	+	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	+	+	.	+	.	.	.	.	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I
Hypericum maculatum	.	.	.	.	.	.	.	.	.	.	.	2	.	+	+	+	.	+	.	.	.	.	+	.	.	.	+	+	+	+	.	.	+	+	.	.	.	+	1	.	+	+	+	II	+	+	1	2	.	.	+	+	+	2	.	.	+	.	.	+	.	+	.	.	.	.	+	.	+	+	.	+	.	.	.	.	.	III
Bellardiochloa violacea	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	3	.	+	.	.	4	2	+	.	+	II	.	.	.	.	+	.	.	+	.	.	+	2	+	.	+	.	.	.	2	1	.	.	+	.	.	.	.	.	.	.	+	.	.	II
Festuca nigrescens	.	.	.	.	.	.	.	+	.	.	.	+	.	2	.	.	.	.	+	2	.	.	+	+	.	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	+	2	.	II	.	.	.	+	+	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	II
Geum montanum	.	+	.	+	.	1	.	1	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	II	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Potentilla ternata	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	+	+	.	.	+	II	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla flabellata	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	+	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Avenula versicolor	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Gentianella bulgarica	.	.	+	.	+	+	.	.	.	+	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	I	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	+	.	.	I
Ligusticum mutellina	.	.	1	1	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
*Scorzonera * rosea*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Veronica officinalis	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I	+	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Viola dacica	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Nardetalia and Nardo-Callunetea																																																																														
Festuca rubra	.	2	2	2	2	2	1	1	2	1	2	.	3	+	2	.	.	2	+	.	.	.	.	.	1	1	1	1	.	.	.	2	.	+	.	2	.	+	3	3	+	+	+	IV	+	1	.	+	.	.	.	+	+	3	+	+	.	.	.	1	.	+	1	+	.	.	+	.	1	+	.	+	+	+	.	.	.	III
Agrostis capillaris	.	.	.	1	1	1	.	.	.	.	+	3	+	.	.	+	.	2	+	.	.	+	2	2	.	.	.	+	.	2	.	.	.	+	.	2	3	.	2	+	.	+	.	III	2	2	.	1	+	.	+	+	2	+	.	+	+	.	.	.	.	.	.	.	.	.	2	+	.	.	.	+	1	.	1	.	.	III
Anthoxanthum odoratum	.	.	.	.	.	.	.	1	.	.	+	+	+	+	.	.	.	+	.	.	+	.	+	+	.	.	+	.	.	+	+	.	.	.	+	+	.	+	+	+	+	.	+	III	+	.	.	.	+	.	+	+	+	.	.	+	+	+	.	+	.	.	.	+	.	.	+	.	+	.	+	+	.	+	+	+	.	III
Homogyne alpina	.	1	+	2	2	+	+	+	1	+	+	.	.	2	.	.	+	.	.	+	.	.	+	.	1	.	1	.	.	.	.	2	.	.	.	.	.	.	.	.	+	1	.	III	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.	+	.	+	.	II
Luzula sudetica	.	2	1	2	1	2	1	2	2	1	2	+	2	.	.	.	.	.	.	+	.	.	+	+	1	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	III	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	+	+	II
Luzula multiflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	2	+	+	.	+	.	.	.	.	+	.	.	+	.	+	.	.	+	.	.	+	+	2	+	+	.	.	II	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	I
Rumex acetosella	.	.	.	.	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	+	.	+	+	.	+	+	.	+	+	.	.	.	.	+	.	+	+	.	+	+	.	.	II	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	I
Antennaria dioica	+	.	.	.	.	+	.	+	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	1	.	.	.	.	.	.	.	.	+	+	.	II	.	.	.	+	.	+	.	+	.	.	.	.	+	.	.	+	+	.	+	1	1	+	.	.	.	+	.	.	+	.	+	+	+	III
Ajuga pyramidalis	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula rotundifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	+	+	+	.	.	I
Chamaespartium sagittale	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	I	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	3	.	.	I
Hypochaeris radicata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Luzula campestris	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	I	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Bruckenthalion				
Juniperus sibirica	+ + + + + + + + + + 1 + + 3 1 + 3 2 2 + 2 1 1 + + 3 + + 3 2 3 2 2 1 3 3 3 2 + + 1 3 1	V	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 5	V
Bruckenthalia spiculifolia	+ + + 1 + 1 . + + 1 1 + . 1 . 1 1 + 2 + . . 1 + 2 + + + 2 1 . 2 1 2 . 1 . 3 + + 1 . +	IV	3 3 + 2 3 3 + 4 + + 2 + 4 4 2 2 4 2 4 2 3 3 1 + 3 3 2 1 3 1 2 1 +	V
Genista depressa	. . + ... + ... + 1 . + + 1 . . + . + . . + + . + . . . 2 1 + . . + . 2 + + +	III	1 . 2 . + + . + + . . 1 2 . . 1 . . . 1 + + . 1 1 + 1 . + + + + +	IV
*Jasione * orbiculata*	. . . .	.	. . . . + ... + + ... + ...	I
Loiseleurio-Vaccinietea and Rhododendro-Vaccinietalia				
Vaccinium myrtillus	. + + 1 + 1 + + + + . + + 1 1 1 2 2 2 + + 3 2 + + + + 1 3 2 2 2 2 3 3 2 3 2 + + 3 2 2	V	3 3 2 3 3 3 2 2 3 2 2 2 4 3 3 2 2 1 1 + + 2 2 1 2 2 3 3 3 2 2 2 3	V
V. uliginosum	. + + 1 1 1 + + 1 1 1 . + 2 + 3 + . 2 + + . . . + . 1 . + 1 1 2 . . . . . 2 . . + 2 +	IV	2 1 . . . + + 3 2 2 3 . + 1 + 1 3 1 . + 2 1 . . . . 2 1 2 3 . 4 2	IV
V. vitis-idaea	. + + . + ... + ... + 1 + 2 . . . 1 + + + + + + 2 1 2 1 2 . + ... 2 . .	III	2 3 2 2 2 + 2 2 2 + 3 . 2 3 2 3 2 1 1 2 2 + 2 + 3 2 2 2 2 2 2 + 1	IV
Other species				
Lerchenfeldia flexuosa	+ + . 1 . 1 + 1 + + + + + 2 . + + ... 1 + 1 + . + + 1 + 1 + . . . + + + 2 3 1 .	IV	+ 2 1 1 . + 2 1 2 + + 2 + + . + + 1 1 + . + 2 2 1 2 1 + 2 2 + + 2	V
Luzula luzuloides	. . . . + + + + + + 1 + . + . . + . + + + + + . . + 1 . . . + + . 2 + .	III	2 2 1 + . + + + + + . 1 + + + 3 + + + 1 + + + . 4 1 + + + + + + .	V
Calamagrostis arundinacea	. . . . + ... + . . . + 2 + + . + + . .	I	. . 1 + . + . 3 + . . 1 + 3 3 . + 3 3 + + 1 4 + + 4 4 + . . 3 . .	IV
Carex caryophyllea	. 2 2 2 2 1 2 2 2 2 + . . . + . + . . + ... 2 . + 2 . . . 2 3 . . . . + . . 2 + .	III	3 + . . . 1 . . . . . + + . . . 3 . + . + . . + ... 2 .	II
Acinos alpinus	. . . . + . . . + . + ... + + ... + . . + + + . . + + . + . .	II	+ . + + ... + ... + . + . . . + ... + . .	II
Bistorta major	. . . + . + + . + . . . + + . . . + . . 2 . . + ... + . .	II	. + + ... + ... 2 .	I
Carduus carduelis	. . . . + . . + ... + ... + + . 1 + . + + . . .	II	. . . . + . . + . + ... + ... + . + . . . + ... + . .	II
Chamaecytisus pygmaeus	. . . . + ...	I	. + + ... + ... + . + . 2 . . + + ... + . .	II
Dianthus superbus	. . . . + ...	I	. . . . + . + . + + + . + + . + + . . . + + . .	II
Festuca balcanica	. . . . + . . + . .	I	+ . 2 . . 4 . + 2 . + . + 2 . + ... + . + . + + + + . 2 . + +	III
F. valida	. . . . + . . + . 1 . . . . . . + ... + + . + ...	I	. . . 1 + ... + . . . + 4 . + . + + ... + . + . .	II
Fragaria vesca	. . . .	.	. . + . . . + + . . . + . . + ... + + ...	II
Hieracium pilosella	+ 2 . 1 . 1 + 2 1 . + . + ... + . . + . + ... 1 . . . . + . .	II	. . . . + ... + ...	I
Hypericum perforatum	. . . . + ... + ... 1 . .	I	. . + 1 . . . + . . . + + . . + ... 2 . . + ...	II
Koeleria eriostachya	. . . . . . + ... + ... + . 2 + . . +	I	. . . . + ... + . . + + + . . + . . + . + ...	II
Potentilla crantzii	. + 1 2 . 1 . . + 1 . + + 1 . . + . . 3 . . + + 1 . + ... + . . + + .	III	+ . . . . . + ... + ... + +	I
Rubus idaeus	. . . . + ... + + .	I	. . 2 2 . . 1 . 2 2 . 2 . . 1 + . + ... + + . 2 + 2 + ...	III
Verbascum longifolium s.l.	. . . . + . . . + . + ... + . . + + + + + + . + 1 . . . + + . + . .	II	. . + + + . + . + . . + ... + . + . . . + ... + . .	II
Campanula patula s.l.	. . . + . + ... + + ... + ... + + ... + . .	I	. . + ... + + ... + ... + .	I
C. sparsa	. . . . + . . . + . . + ... + ... + ... + . . +	I	. . . . + ... + ...	I
C. velebitica	. . . . + ... + ... + + .	I	+ . . + . . + ... + ... + ...	I
Galium verum	. . . . + ...	I	. . + ... + ...	I
Geranium macrorrhizum	. . . . + ...	I	. . + ... + . + ...	I
Epilobium montanum	. . . . + + .	I	. . + ... + ...	I
Festuca dalmatica	. . . . 2 . .	I	. . + ... + ... + ...	I
Centaurea napulifera	. . . . + ... + + ... + . . .	I	. . + ... + . . . + ... + ...	I
Chamaecytisus austriacus	. . . . 1	I	. 1 . . . . + ... 1	I
Cirsium appendiculatum	. . . . + ... + . .	I	. . . . + ...	I
Cruciata glabra	. . . . + . + . . + ... + . . + ... + + . + . .	I	. . . . + ... + .	I
C. laevipes	. . . . + ... + ...	I	. . . . . . + ... + ... +	I
Deschampsia caespitosa	. . . . + . . . + . . 2 . . . . 1 . . + + . . + 1 . .	I	. . . . + . . . + ...	I
Dianthus petraeus	. . . . + .	I	. . . + ... + + ... 1 . . . . +	I
Jasione bulgarica	. . . . + . .	I	. . . + ... + ...	I
Lotus corniculatus	. . . . + ... + . + . .	I	. . . .	.
Luzula pindica	. . . . + ... + . . . + ...	I	. . . . + ... + ...	I
Omalotheca sylvatica	. . . . + + ... + . . + ... + . .	I	. . . .	.
Picea abies	. . . .	.	. . r . . . . + ... r .	I

Table 1. Continuation

Pinus sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	I
Plantago subulata	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	I	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	.	I
Poa angustifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	I
Polytrichum juniperinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Potentilla haynaldiana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	+	I																																		I
Rumex acetosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Scabiosa columbaria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Senecio nemorensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	3	+	.	.	.	.	I
Sesleria latifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Silene roemeri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sorbus aria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	I
S. aucuparia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Stellaria graminea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thlaspi kovatsii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Thymus jankae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Trifolium pratense	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Veratrum lobelianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Veronica chamaedrys	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	I	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	+	.	I
Viola tricolor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	+	.	.	.	I	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I

The table includes only species that exceed 3 relevés.

*Scorzonera * rosea* = *S. purpurea* subsp. *rosea*

*Jasione * orbiculata* = *J. laevis* subsp. *orbiculata*

cording to the two mentioned approaches. The final successional stages according to the Dominant approach are the associations of *N. stricta* and *J. sibirica,* with an entire successional series of syngenetically linked sytaxa between them, which actually represent the different successional stages. Mention deserves the fact that the successional stage has one and the same content under both phytocoenological schools. The difference is that while according to the Dominant school each new successional stage represents a new association, under the school of Braun-Blanquet a new syntaxonomic category could be assigned only after a significant change in the ecological conditions and in the floristic composition. The associations *Nardetum strictae* and *Bruckenthalio-Juniperetum sibiricae* represent two opposite points in the successional process. They are syngenetically linked and could be regarded as originating one from the other in the processes of degradation and demutation. In the absence of exact data it is difficult to determine the time period of the degradation phase. The demutation phase, however, could be related to a period of two-three decades during which, in fact, reduction and stopping of the pasture regime have set in.

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Table 2. Corresponding associations defined by different schools.

Referent numbers of tabl.1	Dominant	Braun-Blanquet
1	*Nardus stricta*	*Nardetum strictae* Greb. 1950
2	*Nardus stricta + Agrostis capillaris*	
3	*Festuca rubra – Nardus stricta*	
4	*Nardus stricta + Lerchenfeldia flexuosa*	
5	*Nardus stricta + Carex kitaibeliana*	
6	*Nardus stricta + Vaccinium uliginosum*	
7	*Juniperus sibirica – Nardus stricta + Luzula multiflora*	
8	*Nardus stricta + Potentilla crantzii*	
9	*Deschampsia caespitosa – Nardus stricta*	
10	*Nardus stricta + Alopecurus gerardii*	
11	*Juniperus sibirica – Nardus stricta*	
12	*Nardus stricta + Poa media – Agrostis rupestris*	
13	*Juniperus sibirica – Vaccinium myrtillus – Nardus stricta*	
14	*Nardus stricta + Carex caryophyllea*	
15	*Bellardiochloa violacea*	
16	*Bruckenthalia spiculifolia – Nardus stricta*	
17	*Bellardiochloa violacea – Nardus stricta*	
18	*Vaccinium myrtillus + Lerchenfeldia flexuosa – Nardus stricta*	
19	*Poa media – Nardus stricta*	
20	*Juniperus sibirica – Vaccinium myrtillus – Carex caryophyllea*	*Bruckenthalio-Juniperetum sibiricae* Horvat 1938 emend. Zupančič 1992
21	*Juniperus sibirica – Bruckenthalia spiculifolia*	
22	*Juniperus sibirica – Festuca balcanica – Vaccinium myrtillus*	
23	*Juniperus sibirica – Vaccinium myrtillus*	
24	*Juniperus sibirica – Sesleria latifolia – Bruckenthalia spiculifolia*	
25	*Juniperus sibirica – Festuca balcanica – Bruckenthalia spiculifolia*	
26	*Juniperus sibirica*	
27	*Juniperus sibirica – Calamagrostis arundinacea – Bruckenthalia spiculifolia*	
28	*Juniperus sibirica – Vaccinium myrtillus – Luzula sylvatica*	
29	*Juniperus sibirica – Festuca rubra – Carex kitaibeliana*	
30	*Juniperus sibirica – Poa media*	
31	*Juniperus sibirica – Bellardiochloa violacea*	
32	*Juniperus sibirica – Vaccinium myrtillus – Bruckenthalia spiculifolia*	
33	*Juniperus sibirica – Festuca valida*	
34	*Juniperus sibirica – Luzula luzuloides – Vaccinium vitis-idaea*	
35	*Juniperus sibirica – Bruckenthalia spiculifolia – Carex caryophyllea*	
36	*Juniperus sibirica – Calamagrostis arundinacea*	
37	*Juniperus sibirica – Luzula luzuloides – Bruckenthalia spiculifolia*	
38	*Juniperus sibirica – Calamagrostis arundinacea –Vaccinium myrtillus*	
39	*Juniperus sibirica – Senecio nemorensis – Vaccinium myrtillus*	
40	*Juniperus sibirica – Festuca balcanica – Vaccinium uliginosum*	
41	*Juniperus sibirica – Calamagrostis arundinacea –Chamaespartium sagittale*	
42	*Juniperus sibirica – Vaccinium uliginosum*	
43	*Juniperus sibirica – Vaccinium myrtillus – Carex kitaibeliana*	

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