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Ivana VITASOVIĆ KOSIĆ[1], Federico Maria TARDELLA[2*], Mirko RUŠČIĆ[3], Andrea CATORCI[2]

[1] Department of Agricultural Botany, Faculty of Agriculture, University of Zagreb, Svetošimunska 25, 10000 Zagreb, Croatia
[2] School of Environmental Sciences, University of Camerino, Via Pontoni 5, 62032 Camerino (MC), Italy, *e-mail: dtfederico.tardella@unicam.it (*corresponding author*)
[3] Department of Teacher Study, Faculty of Philosophy, University of Split, Sinjska 2, 21000 Split, Croatia

ASSESSMENT OF FLORISTIC DIVERSITY, FUNCTIONAL COMPOSITION AND MANAGEMENT STRATEGY OF NORTH ADRIATIC PASTORAL LANDSCAPE (CROATIA)

ABSTRACT: European semi-natural calcareous grasslands are species-rich ecosystems, considered as priority habitats by the European Union (92/43/EEC Directive) and judged worthy of conservation. They are in strong decline in extension and are threatened by abandonment throughout Europe. It is known that grasslands management (grazing, mowing) acts as driving force in plant community diversity, which in turn is an important conservation aim of European environmental policies.

The area of current pastoral landscape (about 1000 ha) of the North Adriatic (Ćićarija, Croatia) was studied in order: 1/ to understand which factors drive floristic differentiation – environmental features and/or grassland management conditions, 2/ to identify indicator species sets linked to those factors and 3/ to appraise the effects of management type on the coenological and functional composition of indicator species. 73 phytosociological relevés were carried out; for each of them field data (altitude, aspect, slope and land form), productivity measurements and information on grassland management were collected. Redundancy analysis (RDA) identified a productivity-related soil moisture gradient as the environmental driving force of grassland floristic differentiation. Indicator species analysis (ISA) detected the indicator species sets related to environmental features and management type. The results indicate that undergrazing and the lack of periodic mowing are responsible for the higher total variance of floristic data set explained by environmental parameters rather than by management (use/not use). For the same reasons, the variations that emerged from comparison of the functional characteristics of the indicator species of grazing and of mowing (avoidance strategy, life form, and storage organs) proved more important than those observed in comparing used and abandoned grasslands. The management system adopted (grazing or mowing) appears in turn to be conditioned by the soil moisture/productivity gradient.

KEY WORDS: grasslands, North Adriatic, management, functional traits, social behaviour type

1. INTRODUCTION

European semi-natural calcareous grasslands, species-rich ecosystems, have been deemed priority habitats by the European Union (92/43/EEC Directive) and judged worthy of conservation (Pärtel *et al.* 1999, Norderhaug *et al.* 2000, Myklestad and Sætersdal 2004, Klimek *et al.* 2006). Throughout Europe, owing to their low agricultural productivity (Willems 1990, van Dijk 1991), these managed pastures are in strong decline in extension and threatened by abandonment (Luick 1998, Zervas 1998, Dullinger *et al.* 2003, Sebastià *et al.* 2008). This trend has been also observed in the North Adriatic pastoral landscape (Kaligarič *et al.* 2006) and on the Ćićarija mountainous plateau in Croatia as well.

It is known that grasslands management acts as driving force in plant community diversity (MacDonald *et al.* 2000, Kahmen *et al.* 2002, Wilson *et al.* 2003). However, the use of simple measurements of species richness to understand plant community shifts due to management modification, can lead to misleading conclusions for conservation aims (Campetella *et al.* 2004). To avoid such pitfalls, species grouping by "compositional and functional dimensions" can be a useful tool (Kirby and Thomas 2000, Moola and Vasseur 2004, Gondard *et al.* 2006). In fact, the analysis of plant community coenological composition has been proven as useful in understanding ecosystem dynamics and properties (Noss 1990, Scheiner 1992, Borhidi 1995, Decocq *et al.* 2004). Furthermore, the assessment of functional traits may reduce the plant community complexity (Hobbie *et al.* 1994, Díaz and Cabido 2001). It allows a better understanding of the relationship between environmental features and plant diversity (Díaz and Cabido 1997, Lavorel *et al.* 1997, McIntyre *et al.* 1999, Pillar 1999, Hunt *et al.* 2004) and makes it possible to model floristic and vegetation shifting due to changes in management type or in disturbance intensity (Kelly 1996, Noble and Gitay 1996, Hobbs 1997, Kleyer 1999). Thus, the understanding of plant community coenological and functional composition can contribute to optimizing grassland management strategy.

On the basis of this theoretical framework, our research aim was to assess the current pastoral landscape of a mountainous North Adriatic territory, from "compositional and functional dimensions" points of view. Hence, the research goals were: i/ to understand which factors (environmental features and/or grasslands management conditions) drive grassland floristic differentiation; ii/ to identify indicator species sets linked to those factors; iii/ to appraise the effects of management type on the coenological and functional composition of indicator species groups.

2. STUDY AREA

The study area (about 1000 ha) is located at the north of the Istrian Peninsula, on the Ćićarija mountainous plateau (45°29'56"–45°30'00"N, 13°59'54"–14°00'29"E), ranging from 250–300 to 850–900 m a.s.l., and belongs to the NATURA 2000 network (92/43/EEC Directive) as an important site for habitat 62A0 and bird species conservation. The climate is transitional between mediterranean and continental pre-Alpine, with cool, rainy winters and long, dry summers (Poldini 1989). The mean annual temperature in the karst Ćićarija is 12.6°C, the coldest in February (0–2°C) and the warmest in July or August (18–22°C). Precipitation is about 1500 mm/year, most of which falls in autumn; a less pronounced secondary peak occurs as spring turns to summer. From a bioclimatic viewpoint, the study area belongs to the submediterranean belt (Kaligarič 1997) and the epi-mediterranean zone of the mediterranean-mountain vegetation belt (Čarni 2003). The territory is characterised by karstic phenomena (dolines, caves, *etc.*); the bedrock consists of limestone; soils are generally brown, shallow and clasts-rich. Pastures are for the most part undergrazed because of low density of grazers (sheep) or abandoned, while meadows are not regularly mown or, in some cases, originate from seeded meadows.

3. METHODS

3.1. Data collection

Data collection was planned in order to sample all the topographic conditions related to altitude, aspect, slope and land form and all types of grassland use (mowing, grazing, mowing abandonment and grazing abandonment).

During 2009, 73 relevés were carried out using Braun-Blanquet's method (1964) in 10 × 10 m plots (100 m^2). Floristic nomenclature followed "Index Florae Croaticae" (Nikolić 1994, 1997, 2000) and "Flora d'Italia" (Pignatti 1982). Field data concerning altitude, aspect, slope, land form and information on grassland management were collected for each plot. Productivity was measured during the vegetation season 2009; samples of grassland (fresh green matter) were mown in 1 × 1 m plots with the quadrat method (Whalley and Hardy 2000) in three vegetation periods (spring, summer, autumn), each in five repetitions. Furthermore, some plant traits (life form, life span, storage organs, vegetative propagation, avoidance strategy and leaf form) were selected in order to assess grasslands functional composition. Data were gathered from the BiolFlor database (Klotz *et al.* 2002) and Pignatti (1982); the data set was also integrated by field observations.

3.2. Data elaboration

Field data, productivity and management type were expressed in classes (Table 1); Braun-Blanquet's values were transformed into average cover percent. Redundancy analysis (RDA) was performed on a matrix made up of 73 relevés × 245 variables (240 species and 5 environmental parameters) to identify the variance percentage of the floristic data set explained by the selected parameters and the relationships among them. Another RDA was run on a matrix of 73 relevés × 242 variables (240 species and 2 parameters, namely grazing/grazing abandonment and mowing/mowing abandonment) to assess the variance percentage explained by grasslands management. To this end, the least frequent species (frequency <3%) were excluded from the analysis. Indicator species analysis (ISA) on two matrices made up of relevés × species (cover %) and relevés × environmental data and management type (classes) was carried out to assess species correlation to environmental parameter classes and grasslands use. The statistical significance of the observed maximum indicator values for species was verified for each parameter through the Monte Carlo test based on 5000 permutations. Indicator values greater than 33.3 were considered of interest. Species highlighted as indicators of more than one environmental parameter class were listed only as indicators of the class showing the highest indicator value. Median bioindication values of the resulting species groups (environmental and management indicators) were calculated in order to test their ecological meaning (Pignatti 2005). Social behaviour type composition of management indicator species groups (relative frequency) was analyzed to assess trends linked to

Table 1. Classes of the environmental parameters used for statistical elaborations.

Parameter		Classes
Altitude (m a.s.l.)	1	< 650
	2	≥ 650
Aspect	1	Southern (SE–WNW)
	2	Flat
	3	Northern (NW–ESE)
Slope (°)	1	> 15°
	2	6–15°
	3	0–5°
Land form	1	Convexity
	2	Concavity
	3	Flat
Productivity (t ha^{-1})	1	4.0–7.0
	2	7.1–10.0
	3	10.1–13.0
Management	1	Grazing abandonment
	2	Mowing abandonment
	3	Grazing
	4	Mowing

use/abandonment. Social behaviour types were assessed in accordance with Mucina *et al.* (1993), Biondi *et al.* (2001, 2005), Aeschimann *et al.* (2004) and Čarni and Franjic (2005). Furthermore, to compare management indicator species groups in regard to the composition of trait modes, Multi-response permutation procedures (MRPP), applied using Sørensen distance, were run for each trait on two matrices: indicator species × trait modes (weighted by the average species cover values within relevés belonging to the management class of each group) and indicator species × grasslands use classes. Statistical analyses were carried out using the SYN-TAX 2000 (Podani 2001) and PCORD 5.0 (McCune and Grace 2002, McCune and Mefford 2006) packages.

4. RESULTS

Redundancy analysis (RDA) concerning environmental features shows that canonical axes explain 12.65% of total variance (Table 2). The first axis, which explains 5.27% of total variance (41.64% of the interset relation variability), is related to a combination of factors acting together (land form, slope, aspect and productivity). Positive values are related to relatively moist conditions (flat or gentle slopes, characterized by high productivity), while negative ones are linked to dryer conditions (moderate slopes with lower productivity). The second axis, explaining 2.85% of total variance (22.51% of interset relation), is related to altitude; positive values are linked to the highest altitudes, negative ones to lower altitudes. The redundancy analysis, performed to identify the amount of variability in floristic data set explained by the different management uses (grazing and mowing), shows that canonical axes explain about 8.19% of total variance (4.76 and 3.43% for axes 1 and 2 respectively); mowing is negatively tied to axis 1, while grazing is positively linked both to axis 1 and 2 (Table 3).

Indicator species analysis (ISA) pointed out the presence of species significantly related to the variables classes. Indicator species of the same class were grouped together; the resulting sets were further grouped according to the main gradient of soil moisture/productivity: Slope 1, Aspect 1, Land form 1 and Productivity 1 (low soil moisture/low productivity); Slope 2, Land form 2, Productivity 2 (intermediate conditions); Aspect 2 and 3, Slope 3, Land form 3, Productivity 3 (high soil moisture/high productivity). Indicator species of grasslands use were listed separately: grazing abandonment, mowing abandonment, grazing and mowing. All the above mentioned species groups are shown in the APPENDIX.

Results of bioindication values analysis for soil moisture/productivity and management indicator species groups are reported in Table 4. The low soil moisture indicator species group is characterized by higher light and temperature and lower median moisture values than the other ones, while the high moisture indicator species group is linked to higher moisture and soil reaction values. Indicators of intermediate conditions show an intermediate moisture value. Indicator species of grasslands use and abandonment show the same soil bioindication values,

Table 2. Summary statistics of Redundancy analysis axes. Scores for environmental parameters and productivity on ordination axes are also shown.

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Eigenvalue	12.64	6.83	4.97	3.49	2.42
Eigenvalue as percentage of total in species data set	5.27	2.85	2.07	1.45	1.01
% variance of interset relation	41.64	22.51	16.38	11.49	7.97
Scores:					
Altitude	–0.105	0.705	–0.573	–0.403	0.041
Aspect	0.270	0.111	0.303	0.586	0.693
Slope	0.670	–0.273	–0.471	–0.270	0.426
Land form	0.737	–0.453	–0.461	0.037	0.194
Productivity	0.961	0.265	0.009	0.073	–0.024

Table 3. Summary statistics of Redundancy analysis axes. Scores for type of management on ordination axes are also shown.

	Axis 1	Axis 2
Eigenvalue	11.41	8.24
Eigenvalue as percentage of total in species data set	4.76	3.43
% variance of interset relation	58.07	41.93
Scores:		
Grazing/grazing abandonment	0.849	0.529
Mowing/mowing abandonment	–0.997	0.081

Table 4. Results of bioindication values analysis of differential species groups indicated by ISA (Indicator Species Analysis) for soil moisture/productivity and grasslands use.

	Light	Temp.	Moisture	Soil reaction	Nutrients
Low soil moisture/low productivity	7.5	6.0	3.0	7.0	3.0
Intermediate conditions	7.0	5.0	3.5	7.0	3.0
High soil moisture/high productivity	7.0	5.5	4.0	7.5	3.0
Used grasslands	8.0	6.0	3.0	7.0	3.0
Grazing	8.0	6.0	3.0	7.0	2.0
Mowing	7.0	6.0	4.0	8.0	3.0
Not used grasslands	7.0	7.0	3.0	7.0	3.0
Grazing abandonment	7.0	7.0	3.0	7.0	2.0
Mowing abandonment	6.0	5.0	4.0	7.0	3.0

while mown/unmown meadows show higher nutrient and moisture median values than grazed/ungrazed pastures.

Analysis of social behaviour types composition of grasslands management indicator species groups (Table 5) shows that abandoned pastures have a higher percent of successional species than grazed ones. Instead, all indicator species of abandoned meadows are typical of pastures, while mown grasslands show a quite heterogeneous composition.

Pairwise comparison of indicator species average cover values of grazed pastures with those of ungrazed ones highlights significant differences for life span and leaf form. Comparison of grazing *vs* mowing indicates differences for avoidance strategy, storage organs and life form, while leaf form is the only trait showing significant differences when comparing grazing abandonment and mowing abandonment indicator species groups (Table 6). Instead, significant differences were not emphasized between mowing and mowing abandonment species groups.

5. DISCUSSION

The soil moisture gradient, due to a combination of topographic factors (slope, aspect and land form), and the related productivity value, turned out to be the main driving forces of grasslands floristic differentiation in the study area (Tables 2 and 3). This result is in accordance with many publications (*e.g.* Bratli and Myhre 1999, Alard and Poudevigne 2000, Ejrnæs and Bruun 2000, Šeffer *et al.* 2002, Galvánek and Lepš 2009) that consider moisture as one of the most important ecological factors influencing floristic composition of grassland communities. Actually, bioindication values analysis of soil moisture and productivity indicator species groups emphasized the presence of a moisture gradient (Table 4). Bioindication values analysis of management indicator species groups (Table 4) indicates that differences in soil moisture and nutrient content (factors both acting on productivity) are not linked to use/not use, but to the management type (grazing/mowing). Management, in turn, is influ-

Table 5. Social behaviour types composition of indicator species groups (in %) relative to each grasslands management type.

Management type	Pasture	Meadow	Successional and ruderal
Grazing	93	0	7
Grazing abandonment	71	0	29
Mowing	46	36	18
Mowing abandonment	100	0	0

Table 6. Multi-response permutation procedures (MRPP) results for plant traits of management indicator species. Only traits showing statistically significant differences in pairwise comparisons (grazing/grazing abandonment, mowing/mowing abandonment, grazing/mowing and grazing abandonment/mowing abandonment) are reported (T – test statistics; A – chance-corrected within-group agreement; *P* – probability of a smaller or equal weighted mean within-group distance).

Comparison	Trait	*T*	*A*	*P*
Grazing *vs* grazing abandonment	Life span	–3.737	0.118	0.008
	Leaf form	–2.804	0.082	0.017
Grazing *vs* mowing	Avoidance strategy	–7.569	0.180	0.000
	Storage organs	–2.363	0.028	0.021
	Life form	–2.276	0.040	0.032
Grazing abandonment *vs* mowing abandonment	Leaf form	–2.276	0.141	0.011

enced by morphological factors (meadows grow on flat, semiflat or slightly concave land forms with deep soils, while pastures on rocky tops or slightly to moderately steep slopes with shallow soils). Further evidence of the main role played in floristic composition differentiation by physical factors rather than land use, is the total variance of the floristic data set explained by environmental parameters that is higher than variance explained by management (Tables 2 and 3). This is probably due to the low intensity use of the pastoral landscape. In fact, it is well known that grazing and mowing are strong driving forces in biodiversity determination (Milchunas and Lauenroth 1993, Biondini *et al.* 1998, Collins *et al.* 1998, Adler *et al.* 2001, Bullock *et al.* 2001, Frank 2005, Altesor *et al.* 2006, de Bello *et al.* 2006, 2007, Catorci *et al.* 2011); thus, conversely, it is possible to state that undergrazing and not regular mowing (low disturbance) lead to floristic homogenization of the system. However, some differences related to pastures or meadows use/not use have been highlighted as well.

As regards the observed shifts in the composition of social behaviour types of indicator species groups (Table 5), the increasing percent value of successional species in abandoned pastures is due to the entry of forest edge species, which are not endowed with defence strategies from grazing. The observed change in floristic composition of meadows from mown to unmown grasslands (loss of all meadow species, successional and ruderal species in favour of pasture ones) can be explained considering that, in accordance with Catorci and Gatti (2010), the occurrence of the meadow characteristic species set is linked to the concomitant presence of mowing, high soil nitrogen content and high soil available water capacity, so that the abandonment of mowing and/or fertilization determines the loss of meadow species in favour of the pasture ones. In hay meadows, competition for light after abandonment and the higher water and soil nitrogen content, allow the invasion of *Brachypodium pinnatum* (L.) P. Beauv. subsp. *rupestre* (Host) Schübl. et M. Martens, which quickly spreads by means of rhizomes (Grime *et al.* 1988) and tends to form extensive patches.

The occurrence of successional half-shadow species in abandoned pastures explains the decreasing trend of median values of light bioindication (Table 4), as well as the establishment of competitive tall grasses in abandoned meadows, which decreases light availability at the soil level and selects half-shadow-demanding species.

As regards functional assessment of indicator species groups, the most significant differences were found again comparing grazing and mowing systems rather than use and not use (Table 6). In fact, grazed and ungrazed pastures significantly differ only in life span data (higher mean abundance of polycarpic perennial indicator species in grazed pastures) and leaf form data (exclusive presence of species with non-graminoid leaves in ungrazed pasture indicators group), while significant differences between mowing and mowing abandonment species groups were not emphasized at all.

Grazed and mown grasslands, instead, show significant differences in avoidance strategy, storage organs and life form of the plant species. In the study area, species of the grazed grasslands are characterized by three kinds of avoidance strategy (scleromorphic/hairy leaves, presence of spines and toxicity), in accordance with the resource availability model, which predicts that species subjected to grazing select avoidance strategies in dry (less-productive) systems (Coley *et al.* 1985, Dìaz *et al.* 2007). All mowing indicator species, instead, lack avoidance mechanisms; in fact, in more humid and productive grasslands such as the species-rich grass meadows of the study area, species do not allocate resources to produce antiherbivore defence structures, but devote them to new photosynthetic tissue (Coley *et al.* 1985). In fact, it is known that several species appear to be very successful in overcoming high defoliation pressure through their regrowth capacity (van der Meijden *et al.* 1988). Moreover, regrowth strategy is typical of the most productive grasslands, as it provides the ability to compete when the potential for resource uptake is high (Maschinsky and Whitham 1989, Skarpe 2001). Some of mown grassland indicator species belong to the *Fabaceae* family (such as *Medicago sativa* L., *Trifolium pratense* L. and *Onobrychis viciifolia* Scop.), which, in fact, is known to be favoured by mowing (Lavorel *et al.* 1999, Ilmarinen and Mikola 2009, Catorci *et al.* 2011).

All mowing indicators, unlike grazing ones, are endowed with storage organs (in particular primary storage roots, pleiocorm and rhizome-like pleiocorm), the occurrence of which is regarded as a tolerance mechanism that in productive systems allows plants to develop new photosynthetic tissue in response to disturbance (Chapin *et al.* 1990). Avoidance strategy and storage organs, as well as vegetative propagation, instead, do not exhibit a significant response comparing use/not use both in pastures and in meadows, in contrast with what one would expect in theory, probably because of the too low management intensity.

In the grazing indicator species group, the presence of chamaephytes can be interpreted in terms of avoidance strategies (they have scleromorphic/pubescent leaves or are toxic, for example *Teucrium chamaedrys* L. and *Euphorbia nicaeensis* All.), while the presence of rosulate hemicryptophytes in the mowing indicator group can be considered as a plants' escape strategy from mowing. Rosettes, in fact, are well suited to tolerate mowing as well as grazing (Hadar *et al.* 1999, Lavorel *et al.* 1999, Kahmen and Poschlod 2004). The absence of rosulate hemicryptophytes within the grazed pastures indicator species could be related to the very low intensity farming system. In fact, Milchunas *et al.* (1988) hypothesized that the relative importance of avoidance or tolerance strategies diverges with increasing primary production that, in turn, is related to environment stress intensity (Berendse 1994, Silvertown *et al.* 1994). Bullock *et al.* (2001) affirm that this dichotomy may be simplistic and assert that response mechanisms can vary, even within the same grassland, depending on the type of grazing animals. Moreover, Watkinson and Ormerod (2001) suggest that variation in the density of grazing is a key factor in understanding how grazing impacts on plant community functional composition. Thus, the competitive success of the different strategies depends on the relationship between resource availability in the environment and livestock pressure (Skarpe 2001).

The only trait that shows significant differences between grazing abandonment and mowing abandonment indicator species groups is leaf form (there were no species with graminoid leaves in abandoned pastures and there were 50% in the abandoned meadows species group). This trait is probably linked to colonization mechanisms after abandonment; graminoids, in fact, are usually highly competitive, and thus have the advantage in more productive habitats (Grime 2001), such as the Ćićarija meadows.

6. CONCLUSIONS

The analyses performed in this study indicate that undergrazing and not periodic mowing make the pastoral landscape quite homogeneous. Moreover, other studies indicate that intensive farming activities (mechanization of agricultural practices, use of herbicides and chemical fertilizers) also cause landscape homogenization in Central Europe (Poschlod and Wallis DeVries 2002, Robinson and Sutherland 2002, Benton *et al.* 2003, Tscharntke *et al.* 2005). Thus actually, both high and low intensity use are liable to lead to a landscape progressive homogenization. To avoid such threat, in the study area conservation efforts and economic incentives should be mainly directed towards meadows. As a matter of fact, they turned out to be more subjected to the invasion of *Brachypodium pinnatum* subsp. *rupestre* and to the loss of characteristic species and, as stated by Bennie *et al.* (2006), they are more vulnerable than pastures to the loss of floristic diversity because of management abandonment. For this reason, regular mowing should be maintained and incentivized; in specific cases, fertilization might be necessary to improve productivity and preserve the meadow characteristic species set. As regards pastures, instead, since the threat of loss of species diversity is lower, a low grazing pressure should be maintained by grazing rotation, in such a way as to have different disturbance intensity acting at the landscape level. Moreover, in pastures abandoned a long time ago, shrub cuts should be planned.

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APPENDIX. Groups of species highlighted by indicator species analysis (ISA).

Low soil moisture / low productivity

Anthericum ramosum L., *Anthyllis vulneraria* L., *Betonica officinalis* L. subsp. *serotina* (Host) Murb., *Brachypodium pinnatum* (L.) P. Beauv. subsp. *rupestre* (Host) Schübl. *et* M. Martens, *Carex humilis* Leyss., *Centaurea rupestris* L., *Dianthus sylvestris* Wulfen subsp. *tergestinus* (Rchb.) Hayek, *Eryngium amethystinum* L., *Euphorbia cyparissias* L., *Euphorbia verrucosa* L., *Genista sericea* Wulfen, *Genista sylvestris* Scop., *Helleborus multifidus* Vis. subsp. *istriacus* (Schiffn.) Merxm. *et* Podl., *Laserpitium siler* L., *Plantago holosteum* Scop., *Satureja subspicata* Vis., *Sesleria tenuifolia* Schrad., *Stachys subcrenata* Vis., *Stipa pennata* L. subsp. *eriocaulis* (Borbás) Martinovský *et* Skalický, *Teucrium chamaedrys* L., *Teucrium montanum* L., *Thalictrum minus* L.

Intermediate conditions

Briza media L., *Buphthalmum salicifolium* L., *Dianthus ferrugineus* Mill. subsp. *liburnucus* (Bartl.) Tutin, *Dorycnium pentaphyllum* Scop., *Festuca valesiaca* Schleich. *ex* Gaudin, *Gentiana cruciata* L., *Knautia drymeia* Heuff., *Knautia purpurea* (Vill.) Borbás, *Medicago falcata* L., *Rhinanthus freynii* (A.Kern. ex Sterneck) Fiori, *Rhinanthus minor* L., *Satureja montana* L. subsp. *montana*, *Scorzonera austriaca* Willd., *Sedum acre* L., *Trifolium montanum* L., *Trifolium rubens* L.

High soil moisture / high productivity

Festuca rupicola Heuff., *Knautia illyrica* Beck, *Leucanthemum liburnicum* (Fiori) Horvatić, *Medicago lupulina* L., *Medicago sativa* L., *Plantago lanceolata* L., *Scabiosa columbaria* L., *Senecio erucifolius* L., *Seseli libanotis* (L.) W.D.J. Koch, *Trisetum flavescens* (L.) P. Beauv., *Trifolium pratense* L.

Grasslands abandonment

Grazing abandonment – *Dianthus sylvestris* Wulfen subsp. *tergestinus* (Rchb.) Hayek, *Euphorbia cyparissias* L., *Euphorbia triflora* Schott, Nym *et* Kotschy, *Genista sylvestris* Scop., *Laserpitium siler* L., *Thalictrum minus* L., *Scorzonera austriaca* Willd.

Mowing abandonment – *Brachypodium pinnatum* (L.) P. Beauv. subsp. *rupestre* (Host) Schübl. *et* M. Martens, *Briza media* L., *Knautia illyrica* Beck, *Medicago falcata* L.

Grasslands use

Grazing – *Bromus erectus* Huds. subsp. *condensatus* (Hack.) Asch. *et* Graebn., *Carex humilis* Leyss., *Eryngium amethystinum* L., *Euphorbia nicaeensis* All., *Galium corrudifolium* Vill., *Inula hirta* L., *Jurinea mollis* (L.) Rchb., *Melica ciliata* L., *Satureja montana* L. subsp. *montana*, *Satureja montana* L. subsp. *variegata* (Host) P.W. Ball, *Satureja subspicata* Vis., *Stipa pennata* L. subsp. *eriocaulis* (Borbás) Martinovský *et* Skalický, *Teucrium chamaedrys* L., *Verbascum blattaria* L.

Mowing – *Daucus carota* L., *Inula salicina* L., *Leucanthemum liburnicum* (Fiori) Horvatić, *Medicago sativa* L., *Medicago lupulina* L., *Onobrychis viciifolia* Scop., *Plantago lanceolata* L., *Plantago media* L., *Vicia cracca* L., *Trisetum flavescens* (L.) P. Beauv., *Trifolium pratense* L.