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Article

The *Nardus*-rich communities in the northern Apennines (N-Italy): a phytosociological, ecological and phytogeographical study

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With 5 figures, 6 tables, 3 appendices in the text and 5 electronic appendices

Abstract: Secondary grasslands dominated by *Nardus stricta* are an anthropogenic vegetation type that occurs widely through the Europe from lowlands to mountains. These communities have been recently recognized by the European Community as a habitat of priority interest. The aim of the study is to perform a detailed and complete phytosociological scrutiny of this vegetation in the northern Apennines. Further aims are to detect the factors controlling the floristic variation within these communities and to analyse the variations of *Nardus* grasslands along a latitudinal gradient from the northern Alps to the southern Apennines. We processed a set of 134 phytosociological relevés from the northern Apennines through a cluster analysis based on Kendall's tau dissimilarity measure. Results showed the occurrence of two different associations of *Nardus* grasslands (Carlino caulescentis-Nardetum strictae and Violo ferrarinii-Nardetum strictae). Relations between their floristic composition and environmental variables were detected through Redundancy Analysis. The matrix of habitat factors included topographic variables and variables derived from Ellenberg's indicator values. Elevation was the factor explaining most of the floristic variation. From the comparison of 44 synoptic tables from the Alps, Carpathians and Apennines, processed through a NMDS ordination, we detected two main phytogeographic and ecological thresholds along the latitudinal gradient.

Keywords: Ecological Indicators, Nardion strictae, Nardo strictae-Agrostion tenuis, northern Apennines, Numerical syntaxonomy, secondary grasslands

Introduction

Secondary grasslands dominated by mat-grass (*Nardus stricta*) occur throughout the Europe from the plains, where they replace forests and dwarf shrub heaths in the areas heavily browsed and trodden by sheep, to the subalpine vegetation belt of the main mountain ranges (Alps, Pyrenees and Carpathians, forming the Alpine Bioregion), where they result from lightly used pastures or meadows (Peppler 1992) and widely take part to zonations and mosaics with a variety of other grasslands, heaths and mires.

Nardus grasslands are typical of moist, base-poor and infertile soils and, therefore, they mainly occur on siliceous massifs. Nevertheless, mat-grass swards can also be encountered on limestone mountains where the parent materials are covered with an acid loam (Ellenberg 2009). In several European mountain areas, the decreasing profitability of raising living stock led to a loosening of pasturing and many previously intensively grazed pastures have fallen to disuse. This induced a ready reversion of mat-grass swards. At higher altitudes they gave way to subalpine dwarf shrub heaths in many places, whereas at lower altitudes the run-down of ground long occupied by these grasslands hindered any succession to forests. The obvious consequence was a reduction trend of the occurrence of *Nardus* grasslands in several European mountains (MacDonald et al. 2000, Galvánek & Janák 2008, Prévosto et al. 2011). Also for this reason, the conservation value of species-rich *Nardus* grasslands has been recently recognized by the European Community, which has listed them under the Directive Habitat (92/43 CEE) as an habitat of priority interest (code 6230).

In the Italian mountains *Nardus* grasslands are very much centred in the Alps (Lüth et al. 2010), mainly in the outer sectors with higher rainfall (Gerdol & Piccoli 1980, Lausi et al. 1981, Lasen 1983, Pignatti & Pignatti 1983, Bezzi et al. 1984, Poldini & Oriolo 1997, Lonati 2009). In the Apennines, *Nardus*-rich communities are still relatively frequent in the northern Apennines and Apuan Alps (see Lüdi 1943, Barbero & Bono 1973, Credaro & Pirola 1975, Barbero & Bonin 1980, Tomaselli 1994, Viciani & Gabellini 2000, Gabellini et al. 2006, Foggi et al. 2007). As one proceeds along the Apennine chain from North to South, mat-grass pastures become increasingly more rare, due to the warmer and drier summer climate and the predominance of less favourable calcareous bedrocks, where *Nardus stricta* suffers for its inability to obtain enough iron from the soil (Gigon 1971). Nevertheless, *Nardus*-rich communities have a still widespread, but rather local, distribution in the central Apennines (Cortini Pedrotti et al. 1973, Pedrotti 1982, Gigli et al.

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1991, Biondi & Ballelli 1995, Biondi et al. 1999, Di Pietro et al. 2005, Catorci & Gatti 2007, De Sillo et al. 2012). In the southern Apennines, *Nardus* grasslands widely occur over siliceous bedrock within the montane vegetation belt dominated by beech woods in the Sila-plateau (Giacomini & Gentile 1961, Bonin 1978) or they are typically restricted to scattered sites with a prolonged snow-lie in the summit areas of the calcareous massifs (Bonin 1972, Tomaselli et al. 2003, 2007).

The European *Nardus*-rich communities have long been recognized as clearly defined vegetation types. Nevertheless, their definition from a phytosociological perspective is somewhat problematical as to their position within higher classificatory units. That is largely the consequence of mat-grass swards being anthropogenic communities arisen in different ways inside their geographical and altitudinal range and preserving floristic traces of their original natural composition.

Traditionally, the European *Nardus*-grasslands, independently from their altitudinal location, were integrated into the unique order Nardetalia within the class Calluno-Ulicetea (syn. Nardo-Callunetea) (see Oberdorfer 1959, 1978, Marschall & Dietl 1974 and, more recently, Peppler 1992, Peppler-Lisbach & Petersen 2001, Lüth et al. 2010). Differently, other authors agreed in partitioning the European *Nardus*-rich communities into two different phytosociological classes (Calluno-Ulicetea and Caricetea curvulae) regarding their origin as a priority criterion for the syntaxonomic attribution (Ellmauer 1993, Grabherr 1993, Poldini & Oriolo 1997). The former class includes *Nardus* pastures originated by the clearing of deciduous woodlands and the grazing of heathlands, either alone or in conjunction with burning; these communities range from the plains to the montane vegetation belt of the main mountains of western and central Europe, nevertheless the problem of discerning their southern and eastern boundaries has remained unclear (Krahulec 1985). Subalpine and lower alpine *Nardus*-rich communities, deriving from the burning of the original dwarf shrub heaths or the intensive grazing of primary alpine grasslands, were subdivided between the classes Calluno-Ulicetea and Caricetea curvulae, with the boundary between these classes occurring in the lower subalpine belt. These grasslands occur widely through the European mountain systems from Scandinavia to southern Europe showing floristic discontinuities determined by historical factors reflected by their subdivision into different alliances. Among them, *Nardus* grasslands from Pyrenees, Alps, northern Apennines and Carpathians were grouped within the alliance Nardion strictae (see Borza 1934, Braun-Blanquet 1948, 1949, Credaro & Pirola 1975 and many others).

Other authorities (mostly Spanish and Italians) have recently conceived a different classificatory scheme grouping all the Eurosiberian and Mediterranean *Nardus*-grasslands within a dedicated class (Nardetea strictae) (e.g. Molina Abril 1993, Biondi et al. 1999, Rivas Martínez et al. 2002). The shrub communities, most frequently representing the historical precursors of these grasslands, were *a priori* excluded from the class, according to the assumption that a separation between structural vegetation types may be helpful for obtaining more homogeneous vegetation classes and gaining potential character species (see also Bergmeier et al. 1990, Dengler 2003, Michl et al. 2010). According to this, the class Calluno-Ulicetea has been restricted to include only heathland and dwarf scrub vegetation (Theurillat et al. 1995, Rivas Martínez et al. 2002). Nevertheless, with this scheme some difficulties arise for providing a convenient syntaxonomic location for the subalpine and alpine *Nardus*-rich communities of the alliance Nardion strictae. They cannot be, in fact, easily incorporated into the class Nardetea strictae owing to their strict similarities in floristics and environmental relationships with the primary grasslands of Caricetea curvulae.

In this paper we attempt to perform a first detailed and complete phytosociological scrutiny of the *Nardus* grasslands on the whole range of the northern Apennines, with the aim of producing a sound and consistent classification of these communities and in the perspective of carrying out, in the future, a general phytosociological survey on this vegetation in the Italian mountains. The study includes also the ecological interpretation of the vegetation types resulting from the compositional analysis and the analysis of the floristic variation of the *Nardus* communities from the northern Alps to the southern Apennines.

Materials and methods

Study area

The northern Apennines form a 250 km long mountain barrier running in a NW-SE direction and separating the Po plain in the North from the Italian peninsula in the South at latitude about 44° N. Our study sites are located in the Tuscan-Emilian district, representing the core of the mountain system, in the Apuan Alps and in the Pratomagno massif. The latter are secondary chains bordering the main one, to South-West and South-East, respectively (Fig. 1).

The highest peaks in the study area are Mt. Cimone (2165 m) in the Tuscan-Emilian Apennines and Mt. Pisanino (1946 m) in the Apuan Alps, whereas the highest summit in the Pratomagno massif is at 1591 m (Croce di Pratomagno).

The geological framework of the Tuscan-Emilian Apennines is mainly given by sandstones belonging to the Macigno Formation, by medium- to coarse grained sandstones alternating with fine-grained sandstones and siltstones (Mt. Modino Formation) and by fine-grained sandstones alternating with shaly marls ascribed to the

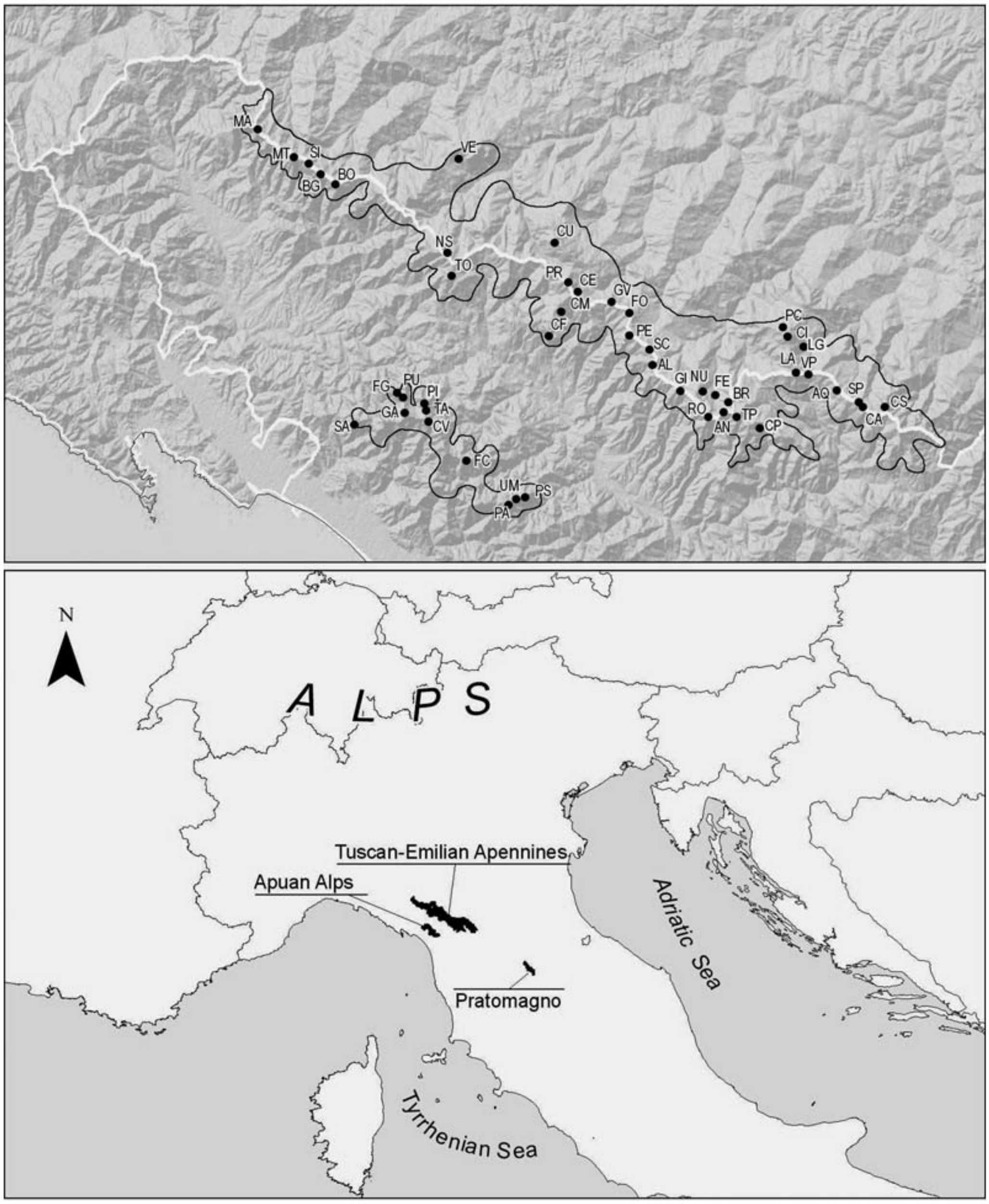


Fig. 1. Schematic map of the study area. The labels of the sites are according to Appendix 2.

Mt. Cervarola Formation (Bruni et al. 1994). The latter are the main substratum also in the Pratomagno massif. Bedrock in the Apuan Alps is more heterogeneous alternating carbonate rocks (limestones, dolomites, marbles), mostly outcropping at the upper areas, and siliceous rocks ("verrucano", porphyroids, sandstones and jaspers), chiefly occurring at low altitudes.

Climatic features of the study area are derived from the thermopluviometric data of 11 stations located above 1000 m of altitude. Main climatic differences within the area concern precipitation. Climate is temperate oceanic with an average annual rainfall exceeding 2000 mm in the Apuan Alps and on the south-western (Tuscan) slope of the Tuscan-Emilian Apennines, both lying closer to the Tyrrhenian sea. Along the Emilian slope of the Tuscan-Emilian Apennines climate is somewhat less oceanic, with an average annual rainfall around 1500 mm. Also the Pratomagno massif, the most distant from the Tyrrhenian coast, experiences a less oceanic climate with an average annual rainfall about 1300 mm.

Materials and statistical analysis

The vegetation was studied following the standard procedures of the Zürich-Montpellier School (Braun-Blanquet

1964), updating the fundamental concepts according to Dengler et al. (2005, 2008). The data set subjected to analysis consists of 134 phytosociological relevés, taken strictly according to the principle of the floristic and structural homogeneity within the sampled vegetation stands and providing a reasonable cover of the whole study area. The bulk of the relevés (114) is original and includes all those taken from throughout the Tuscan-Emilian Apennines and the Apuan Alps, at different sites in order to avoid spatial autocorrelation. The complete list of the sampling sites is reported in Appendix 2 and their spatial distribution is shown in Fig. 1, where each site is designed by a given label. The residual 20 relevés, coming from the Pratomagno massif, were drawn from literature (Viciani & Gabellini 2000).

Nomenclature of plant taxa is according to Conti et al. (2005). Regarding *Juniperus communis* subsp. *alpina* we follow Aeschimann et al. (2004), whereas the binomial *Viola ferrarinii* is derived from Moraldo et al. (2011).

The size of our sample plots shows a considerable variation range. This can be justified considering that many relevés were taken before possible standards for different vegetation classes were suggested (see Chytrý & Otýpková 2003). Anyway, the bulk of relevés ranges from 20 to 100 m^2, differing by a factor of up to 5, considered acceptable by Michl et al. (2010). Smaller and larger plots were excluded from the data set, except for the plots smaller than 20 m^2 occurring close to the summit ridges, where no larger patches were available nearby. These small plots were included within the data set according to the recommendation of Chytrý & Otýpková (2003).

The 134 relevés were numerically classified by a cluster analysis after transforming the Braun-Blanquet cover-abundance estimates according to van der Maarel (1979). Kendall's tau dissimilarity measure was used for the classification, because it is particularly suitable for processing ordinal data such as phytosociological relevés (Podani 2006). As clustering strategy we adopted the hierarchical version of an ordinal procedure (Ord ClAn-H) reported in the package SYN-TAX 2000 (Podani 2001). Further details on this procedure are in Podani (2005). The package SYN-TAX 2000 was also used for the corresponding computations.

To evaluate whether a certain species can be considered as diagnostic for the different classes, orders and the alliances we consulted recent literature (Ellmauer 1993, Grabherr 1993, Molina Abril 1993, Theurillat et al. 1995, Mucina 1997, Poldini & Oriolo 1997, Rivas Martínez et al. 2002, Aeschimann et al. 2004.). We regarded as diagnostic species all those explicitly mentioned in the literature as character species of a class or of its subordinate syntaxa. *Nardus stricta*, regarded as character species of Nardetalia strictae (Calluno-Ulicetea or Nardetea strictae) or also as differential species of Nardion strictae (Caricetea curvulae) was listed as diagnostic in both two classes. The character species of Nardion strictae were computated twice (for both Nardetea strictae and Caricetea curvulae). The relevés were assigned to the class whose diagnostic species were prevailing, after summing up the transformed cover-abundance values (importance values) of the diagnostic species in each relevé (see Dengler et al. 2006a, Michl et al. 2010). The incidence of subordinate phytosociological classes was helpful for interpreting compositional differences between the vegetation types obtained by numerical classification. The incidence of phytosociological classes within the different vegetation types occurring in the northern Apennines were analysed by non-parametric Kruskal-Wallis and Wilcoxon tests. Computations were performed with "coin" library of R version 2.13.2 (2011).

The differential species among the different vegetation types of *Nardus* grasslands from the Tuscan Emilian Apennines and Apuan Alps were statistically defined according to the principle of species fidelity, based on the ϕ coefficient of association (Chytrý et al. 2002). The ϕ values were computed using the software JUICE 7 (Tichý 2002: www.sci.muni.cz/botany/juice). These values are independent of the statistical significance of species occurrence concentration in the different vegetation types, but in the JUICE program significance can be obtained by a simultaneous calculation of Fisher's exact test. We considered a species as differential of a subassociation if $\phi > 0.40$ and $P < 0.01$ and differential of a variant if $\phi > 0.40$ and $P < 0.05$. These threshold values of ϕ were chosen because it yielded neither too long nor too short lists of diagnostic species for the different vegetation subunits (see Illyés et al. 2007).

Nomenclature of the syntaxa was according to the rules defined by the International Code of Phytosociological Nomenclature (Weber et al. 2000), from here ICPN. The syntaxonomic scheme and the nomenclaturally relevant decision and proposals (typifications of new syntaxa, corrections of names) are reported in Appendix 1.

The analysis of floristic variation within *Nardus* grasslands as function of environmental variables was performed through redundancy analysis (RDA), that is a multivariate analogue of simple linear regression. This method is a valid alternative to canonical correspondence analysis (CCA) that is widely adopted for the ecological interpretation of vegetation data, even though it confers an unduly influence to rare species on the analysis and a higher weight to the more species-rich vegetation stands (Legendre & Gallagher 2001). We used a RDA based on the Hellinger distance (Legendre & Legendre 1998) applied to both the vegetation matrix and to that of the explanatory variables. The topographic variables (elevation and aspect) were directly measured in the field, whereas the climatical and pedological variables were derived from Ellenberg's indicator values adapted to the Italian flora by Pignatti et al. (2005). In particular, we considered the following ecological indicators: Light (L), Temperature (T), Moisture (U), Nitrogen (N), Continentality (K) and Soil Reaction (R). The value of each ecological indicator for each relevé was obtained by calculating the weighted average of all values of those species occurring in the relevé (Diekmann 2003).

Prior to analyses, species abundance values were standardized (Hellinger transformation) to make them suitable to linear ordination methods (Legendre & Gallagher 2001). Explanatory variables were standardized to zero mean and unit variance (z-scores) to make them dimensionally homogeneous; before standardization, aspect angular data were transformed into numerical values according to Storm (1996). Collinearity among explanatory variables was checked by computing variance inflation factors (Neter et al. 1996) with a cut-off value of 5. In order to select those variables significantly contributing to explain the floristic variation, a forward selection was run. To prevent the inflation of the overall type I error and the inflation of the amount of explained variance, the double-step procedure proposed by Blanchet et al. (2008) was applied. However, the use of ecological indicators can produce biased results, due to the "similarity issue" (Zelený & Schaffers 2012). In order to partially take into account this statistical artefact, which results in a higher probability of obtaining significant results for the ecological indicators compared to variables directly measured, RDA with significant ecological indicators was performed, and the correlations with the canonical axes were checked using the modified test proposed by Zelený & Schaffers (2012), eventually dropping non-significant ecological indicators.

Furthermore, a model selection with permutation test was used to detect the most significant explanatory variable. Finally, the distribution of vegetation types along the gradient of this environmental factor was represented through a box-plot diagram and analysed by non-parametric Kruskal-Wallis and Wilcoxon tests. Computations were performed with "coin", "vegan" and "packfor" libraries of R version 2.13.2 (2011).

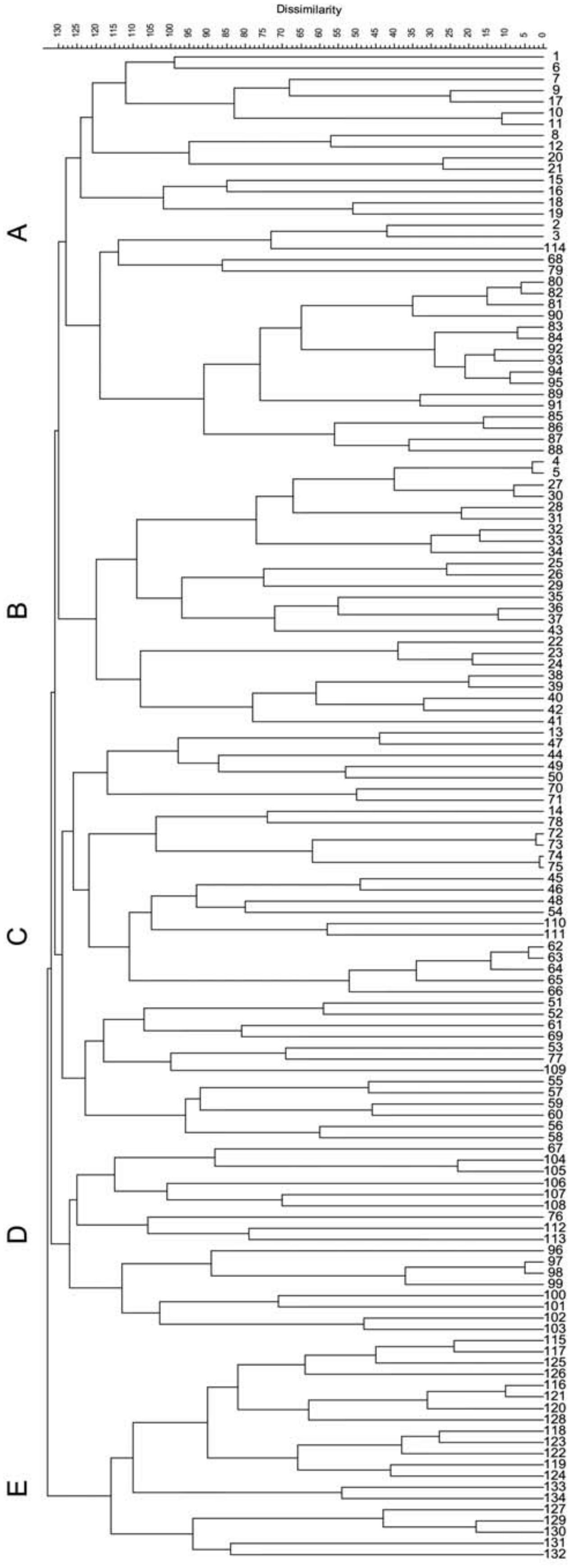
A synoptic table was assembled in order to explore large scale major floristic differences within *Nardus* grasslands along a latitudinal gradient from the Alps to southern Italy, without discussing the syntaxomic allocations of the phytosociological tables used in the analysis. The complete table includes 518 species distributed within 44 columns, each corresponding to an individual table. The frequency values in each column represent the species frequency in each table. The data set includes published and unpublished data of *Nardus* grasslands from the Carpathians (one table), the Alps (most of tables), the northern Apennines (our data) and the central and southern Apennines. The complete list of the original tables and their geographical locations are reported in Appendix 3. The nomenclature of the different sectors of the Alps is according to Marazzi (2005). Species nomenclature is according to Aeschimann et al. (2004) and Tutin et al. (1968–1980).

The compositional gradient was analysed using Non-metric MultiDimensional Scaling (NMDS) as unconstrained ordination technique. The dissimilarity matrix applied in the NMDS was constructed using the Bray-Curtis distances. Also these computations were performed with SYN-TAX 2000 (Podani 2001). In addition, we calculated the percentage values of chorotypes (derived from Aeschimann et al. (2004) and, when necessary, from Pignatti (1982)) and the percentual incidence of phytosociological classes, after summing up the frequency values of the diagnostic species within the 44 synoptic tables. These calculations were used for interpretating the results of NMDS ordination. The incidence of phytosociological classes and chorotypes within the groups of tables obtained by NMDS was analysed by non-parametric Kruskal-Wallis and Wilcoxon tests. Also here computations were performed with "coin" library of R.

Results

Vegetation analysis

The results of the cluster analysis are shown in Figure 2. Five main clusters, each marked with a capital letter, can be clearly distinguished in the classification dendrogram at a dissimilarity cut level of about 130. The most important split within the five-cluster concerns the cluster E (20 relevés) clearly separated from all the other clusters (from A to D) globally comprising 114 relevés. This hierarchical arrangement can be translated into a first syntaxonomical distinction on the basis of the summed up average cover values of diagnostic species within the five clusters (Table 1). The values concerning the two phytosociological classes to which *Nardus*-grasslands are ascribed in the most recent literature (Nardetea strictae and Caricetea curvulae) are the basis for this major subdivision. The really distinctive feature among cluster E and the group of clusters A-C is, in fact, the opposite ratio between the cover-abundance of the diagnostic species of these two classes. The diagnostic species of Caricetea curvulae prevail constantly within group A-C (see also Table 2) and have a low incidence in cluster E, where the diagnostic species of Nardetea strictae are, conversely, especially prominent (Electronic Appendix 1). This is a powerful argument for regarding the *Nardus* grasslands of the northern Apennines as allocable to two different phytosociological classes. Separation is furtherly supported by the significant prominence of the species of Festuco-Brometea, Trifolio-Geranietea and Querco-Fagetea in cluster E (Table 1). The group D has an intermediate position in the dendrogram between the block A-C and the group E. This reflects a floristic assemblage characterized by a balanced mixture of species of Nardetea strictae, Caricetea curvulae and Molinio-Arrhenatheretea.



Cluster E includes all the stands sampled in the woodland clearings close to the summit ridge of the Pratomagno massif. Grasses like *Nardus stricta*, *Festuca rubra* subsp. *commutata*, *Luzula campestris* and *Deschampsia flexuosa* are constant and cover more than 70% in all stands, while *Lotus corniculatus*, *Cruciata glabra* and *Carlina acaulis* subsp. *caulescens* are the only constant species among herbaceous dicotyledons (Electronic Appendix 1). All relevés of the cluster can be ascribed to the same association (*Carlino caulescentis-Nardetum strictae*, CC-NA) as suggested by Viciani & Gabellini (2000, 2006). Nevertheless, the original list of diagnostic species of the association needs to be modified by retaining only, among the original differential species, *Carlina acaulis* subsp. *caulescens*, *Viola eugeniae*, *Thymus pulegioides* and *Rumex acetosella* and adding *Cruciata glabra* and *Carex caryophyllea* as other differential species against the other associations of the alliance (see below).

The syntaxonomic place of the Carlino caulescentis-Nardetum strictae is inside the class Nardetea strictae and the order Nardetalia strictae. Designation of the alliance raises particular difficulties also for the scarcity of comparison data and, for this reason, our proposal has to be regarded as tentative and provisory. The best locus for the association seems to be in the alliance Nardo strictae-Agrostion tenuis owing to its floristic mixture of Nardetea strictae and Molinio-Arrhenatheretea species. The subatlantic alliance of Violion caninae cannot be considered as a reliable alternative for the low occurrence of its diagnostic species. Moreover, the *Nardus* grasslands of the Violion caninae are typical of base-poor soils and centered in the suboceanic parts of Europe, whereas on the Pratomagno massif bedrock is given by sandstones alternating with marls fairly rich in carbonates and climate is not so oceanic.

The Nardo strictae-Agrostion tenuis was described from the montane vegetation belt of the Western Carpathians (Sillinger 1933) and, recently, it was reported also from the south-eastern Alps (Poldini & Oriolo 1997). The prominence of thermophilous species belonging to the class Festuco-Brometea (*Carlina acaulis* subsp. *caulescens*, *Thymus pulegioides*, *Carex caryophyllea*) provides distinctive floristic features within the alliance to the stands from Pratomagno.

The clusters from A to D comprise the *Nardus stricta*-rich grasslands occurring in the Tuscan-Emilian Apennines and the Apuan Alps. The general predominance in both frequency and cover-abundance of the diagnostic species of the class Caricetea curvulae and Caricetalia curvulae in these clusters puts them in these syntaxa (Table 1 and 2). At the alliance level, their affiliation is clearly

Fig. 2. Classification dendrogram of 134 relevés of *Nardus* grasslands in the northern Apennines. Capital letters indicate the main clusters resulting from classification.

Table 1. Average values of diagnostic species of the phytosociological classes within the different subassociations of the Violo ferrarinii-Nardetum strictae and the Carlino caulescentis-Nardetum strictae. *P*-values for each class refer to Kruskal-Wallis test, whereas different letters indicate significant differences (Wilcoxon test, $P < 0.05$) between class pairs. VF-NA ty = Violo ferrarinii-Nardetum strictae subass. Typicum; VF-NA cg = Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis; VF-NA lm = Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae; VF-NA pr = Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici; CC-NA = Carlino caulescentis-Nardetum strictae. Cluster as in Fig. 2.

Vegetation Types	VF-NA ty	VF-NA cg	VF-NA lm	VF-NA pr	CC-NA	*P*-value
Cluster's groups	A	B	C	D	E	
Caricetea curvulae	23.0 ± 6.0 D	17.2 ± 4.3 BC	18.9 ± 5.3 C	14.6 ± 6.0 B	7.1 ± 2.7 A	< 0.001
Nardetea strictae	20.3 ± 5.9 B	13.4 ± 2.0 A	18.2 ± 3.7 B	16.9 ± 5.8 AB	18.3 ± 4.4 B	< 0.001
Molinio-Arrhenatheretea	5.3 ± 4.5 A	4.8 ± 2.6 A	7.5 ± 3.9 B	13.2 ± 4.4 C	10.8 ± 5.7 C	< 0.001
Festuco-Brometea	0.4 ± 0.8 A	–	2.6 ± 2.4 B	0.8 ± 1.8 A	6.8 ± 3.4 C	< 0.001
Elyno-Seslerietea	1.2 ± 2.4 A	2.5 ± 1.9 C	2.4 ± 1.8 C	2.9 ± 4.3 BC	1.2 ± 1.0 B	< 0.001
Loiseleurio-Vaccinietea	3.4 ± 3.2 B	1.2 ± 1.8 A	3.8 ± 2.9 B	1.1 ± 1.4 A	–	< 0.001
Koelerio-Corynephoretea	1.2 ± 1.3 B	0.1 ± 0.4 A	3.0 ± 2.8 C	1.9 ± 2.3 BC	2.0 ± 1.3 B	< 0.001
Vaccinio-Piceetea	3.5 ± 1.9 B	0.7 ± 1.0 A	2.9 ± 2.1 B	0.9 ± 1.2 A	–	< 0.001
Trifolio-Geranietea	–	–	0.6 ± 1.6 A	0.5 ± 1.0 A	4.2 ± 2.0 B	< 0.001
Querco-Fagetea	0.1 ± 0.3 A	–	0.5 ± 1.0 B	0.8 ± 1.2 B	3.6 ± 2.9 C	< 0.001
Salicetea herbaceae	0.1 ± 0.8 A	1.7 ± 2.1 B	–	–	–	< 0.001
Artemisietea vulgaris	–	0.1 ± 0.4	0.1 ± 0.4	0.4 ± 0.8	0.4 ± 1.0	0.287
Thlaspietea rotundifolii	–	0.1 ± 0.4	–	–	0.4 ± 0.9	0.210
Mulgedio-Aconitetea	–	–	0.1 ± 0.3	0.1 ± 0.5	0.3 ± 0.8	0.496
Epilobietea angustifolii	–	–	0.1 ± 0.4	–	0.1 ± 0.4	0.966

with the Nardion strictae, because a substantial nucleus of species belonging to this alliance finds a place in all stands (Table 2). The four clusters show a certain degree of floristic heterogeneity quite precisely reflected in the dendrogram. Nevertheless, there is a sufficient floristic basis in common among them to be grouped within a single vegetation type that is floristically very close to the association Violo cavillieri-Nardetum strictae, originally described as Violo bertolonii-Nardetum by Credaro & Pirola (1975) (see Appendix 1 for nomenclatural details). Very recently, Moraldo et al. (2011) described *Viola ferrarinii* as a new species replacing *Viola calcarata* L. subsp. *cavillieri* (W. Becker) Negodi in the northern Apennines. As a consequence, the association is named here Violo ferrarinii-Nardetum strictae. *Viola ferrarinii* can be regarded as the only character species of the association.

With the more comprehensive account of this kind of vegetation that is available now (114 relevés versus the only 6 original ones), the association retains its integrity, but it shows to be clearly differentiated into several distinct sub-communities (subassociations and variants) corresponding to the clusters from A to D.

The first cluster (A) is composed by 36 relevés (Electronic Appendix 2). The grasses *Nardus stricta* and *Festuca rubra* subsp. *commutata*, the herbaceous dicotyledon *Geum montanum* and the sub-shrub *Vaccinium myrtillus* are here the only constant species. *Nardus stricta* is generally dominant in all stands, with *Festuca rubra* subsp. *commutata* being often subdominant and *Carex sempervirens*, *Geum montanum* and *Vaccinium gaultherioides* achieving local prominence. The cluster corresponds to the typical subassociation (Violo ferrarinii-Nardetum strictae typicum Gennai, Foggi, Viciani, Carbognani et Tomaselli subass. nova *hoc loco* holotypus rel. 3 of Table 7 in Credaro & Pirola 1975: VF-NA ty), because the species diagnostic of alliance, order and class occur here in a large pool and most of them also with their maximal frequencies (Table 2). The cluster is varied in its floristic composition (Electronic Appendix 2). Relevés from 1 to 19 correspond to the typical variant, whereas relevés from 2 to 88, differentiated by *Anthoxanthum odoratum* subsp. *nipponicum*, *Carex sempervirens*, *Deschampsia flexuosa*, *Plantago maritima* subsp. *serpentina*, *Potentilla erecta* and *Vaccinium gaultherioides* correspond to a *Carex sempervirens*-variant, that can be considered a successional stage in direct transition from *Nardus* grasslands to *Vaccinium* dwarfed heaths. The Violo ferrarinii-Nardetum strictae typicum is strongly confined to the northern slope of the Tuscan-Emilian Apennines, with some fragmentary representation on the southern slope and one stand in the Apuan Alps.

Cluster B includes 24 species-poor relevés, where *Nardus stricta* is overwhelmingly dominant and the grass

Table 2. Synoptic table of four different subassociations of the Violo ferrarinii-Nardetum strictae. In bold types the differential species of subassociations and the corresponding values of phi. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; TC: territorial characteristic species. Abbreviations as in Table 1.

Cluster	A	B	C	D	
Vegetation type	VF-NA ty	VF-NA cg	VF-NA lm	VF-NA pr	**phi**
N. of relevés	36	24	37	17	
Nardion strictae					
Nardus stricta (ALD)	100	100	100	94	
Festuca rubra subsp. commutata (ALD)	94	79	97	82	
Geum montanum	86	75	89	24	
Potentilla aurea	53	33	16	35	
Plantago alpina	28	**75**	13	6	***55.7***
Leontodon helveticus	72	4	19	24	
Viola ferrarinii	28	13	40	6	
Gentiana acaulis	.	4	32	24	
Trifolium alpinum	22	.	5	.	
Pedicularis tuberosa	6	.	13	.	
Gnaphalium sylvaticum (ALD)	.	.	3	6	
Solidago virgaurea subsp. minuta	3	.	.	.	
Caricetalia & Caricetea curvulae					
Alchemilla gr. alpina	56	58	76	35	
Anthoxanthum odoratum subsp. nipponicum	64	13	76	53	
Agrostis rupestris	8	13	8	**24**	
Euphrasia minima	17	4	8	18	
Carex sempervirens (TC)	75	46	16	.	
Phyteuma hemisphaericum	53	42	27	.	
Juncus trifidus	8	13	5	.	
Centaurea uniflora subsp. nervosa	3	.	5	6	
Euphrasia alpina	3	.	3	6	
Hieracium alpicola	3	.	.	6	
Luzula lutea	6	.	3	.	
Festuca paniculata subsp. paniculata	3	.	3	.	
Botrychium lunaria	.	.	.	24	***43.3***
Armeria marginata	.	.	.	12	
Festuca riccerii	.	.	11	.	
Nardetea strictae					
Carex leporina	8	13	8	6	
Ranunculus apenninus	11	4	5	6	
Luzula multiflora	25	.	**81**	71	***42.9***
Potentilla erecta	64	.	38	35	
Antennaria dioica	17	.	13	29	
Hieracium pilosella	11	.	24	24	
Dianthus deltoides	11	.	19	18	
Carex pallescens	31	.	3	.	
Veronica officinalis	.	.	19	12	
Meum athamanticum	.	.	5	18	
Ranunculus pollinensis	.	.	.	**35**	***53.9***
Carex pilulifera	17	.	.	.	
Coeloglossum viride	.	.	.	6	
Molinio-Arrhenatheretea					
Poa alpina	28	**100**	43	24	***59.3***
Phleum rhaeticum	44	33	16	**94**	***54.5***
Sagina glabra	28	25	16	65	
Trifolium pratense	11	17	22	**76**	***56.0***
Lotus corniculatus	6	4	38	**65**	***47.1***
Alchemilla gr. vulgaris	3	.	13	**71**	***68.4***
Bistorta officinalis	31	.	38	6	
Deschampsia cespitosa	44	13	3	.	
Agrostis capillaris	6	.	16	18	
Crocus vernus	.	4	16	6	
Cerastium holosteoides	3	.	11	6	
Rumex nebroides	.	4	5	6	
Taraxacum officinale	3	.	5	6	
Genista tinctoria	3	.	**38**	.	***52.9***
Achillea millefolium	.	.	13	24	
Leontodon hispidus	6	.	.	12	

Table 2. cont.

Cluster	A	B	C	D	
Vegetation type	VF-NA ty	VF-NA cg	VF-NA lm	VF-NA pr	**phi**
N. of relevés	36	24	37	17	
Stellaria graminea	.	.	3	12	
Sanguisorba officinalis	11	.	3	.	
Ajuga reptans	.	.	3	6	
Trifolium repens	6	.	3	.	
Rhinanthus serotinus	3	.	3	.	
Elyno-Seslerietea					
Crepis aurea subsp. glabrescens	11	**87**	3	29	*67.5*
Galium anisophyllon	14	4	35	6	
Trifolium thalii	3	4	3	6	
Polygala alpestris	8	8	**57**	.	*57.3*
Carum apuanum	.	.	3	6	
Gentiana verna	.	.	.	**29**	*48.8*
Phyteuma orbiculare	.	.	.	12	
Taraxacum aemilianum	.	.	.	12	
Lotus alpinus	8	.	.	.	
Pulsatilla alpina subsp. millefoliata	.	.	8	.	
Minuartia verna	.	.	5	.	
Festuco-Brometea					
Carlina acaulis subsp. caulescens	11	.	40	12	
Pimpinella saxifraga	8	.	35	12	
Cerastium arvense subsp. suffruticosum	3	.	27	6	
Dactylorhiza sambucina	.	.	8	.	
Carex macrolepis	.	.	5	.	
Koelerio-Corynephoretea					
Thymus praecox subsp. polytrichus	6	4	57	41	
Plantago maritima subsp. serpentina	44	.	35	12	
Dianthus sylvestris	.	.	30	6	
Rumex acetosella	.	.	5	24	
Salicetea herbaceae					
Luzula alpinopilosa	3	**46**	.	.	*59.5*
Gnaphalium supinum	3	13	.	.	
Sedum alpestre	.	8	.	.	
Carex foetida	.	8	.	.	
Loiseulerio-Vaccinietea					
Hypericum richeri	39	21	73	41	
Vaccinium gaultherioides	64	33	32	.	
Juniperus communis subsp. alpina	28	4	35	.	
Empetrum hermaphroditum	6	.	.	.	
Vaccinio-Picetea					
Vaccinium myrtillus	92	33	78	41	
Luzula sieberi	25	.	22	.	
Homogyne alpina	33	.	11	.	
Vaccinium vitis-idaea	17	.	-	.	
Calluno-Ulicetea					
Calluna vulgaris	.	.	16	.	
Trifolio-Geranietea					
Phyteuma scorzonerifolium	.	.	.	18	
Seseli libanotis	.	.	11	.	
Cruciata glabra	.	.	8	.	
Querco-Fagetea					
Hieracium murorum	3	.	3	.	
Viola reichenbachiana	.	.	.	**35**	*53.9*
Anemone nemorosa	.	.	19	.	
Other companions					
Deschampsia flexuosa	33	4	**76**	29	*48.3*
Brachypodium genuense	6	13	**51**	6	*48.0*
Campanula scheuchzeri	.	8	27	24	
Cirsium morisianum	.	4	5	18	
Soldanella alpina	.	4	.	6	
Cirsium bertolonii	.	.	3	6	

Poa alpina and the herbaceous dicotyledon *Crepis aurea* subsp. *glabrescens* are its most frequent associated. Other species attaining uniformly high frequency are *Festuca rubra* subsp. *commutata*, *Plantago alpina* and *Geum montanum* (Electronic Appendix 3). The cluster is differentiated by *Crepis aurea* subsp. *glabrescens*, *Luzula alpino-pilosa*, *Plantago alpina* and *Poa alpina* (Table 2); moreover, the chionophilous species of the class Salicetea herbaceae are here significantly prominent and those of Nardetea strictae and Koelerio-Corynephoretea have their significantly poorest representation (Table 1). In reason of these floristic distinctive features, the community can be recognised as an independent subassociation, for which we propose the name Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis Gennai, Foggi, Viciani, Carbognani et Tomaselli subass. nova *hoc loco* holotypus rel. 32 in Table 6 and Electronic Appendix 2: VF-NA cg. Subassociation is restricted to the northern slopes of the highest summits Tuscan-Emilian Apennines, at sites close to the summit ridges.

Cluster C comprises 37 relevés, where *Nardus stricta* is mostly dominant or occasionally co-dominant with *Festuca rubra* subsp. *commutata* that, in turn, can attain dominance at some stands. Other constant species are the herbaceous dicotyledon *Geum montanum* and the grass *Luzula multiflora*. Further important species through the community are the grasses *Anthoxanthum odoratum* subsp. *nipponicum* and *Deschampsia flexuosa*, the herbaceous dicotyledons *Alchemilla* gr. *alpina* and *Hypericum richeri* and the sub-shrub *Vaccinium myrtillus* (Electronic Appendix 4). The cluster is differentiated by *Brachypodium genuense*, *Deschampsia flexuosa*, *Genista tinctoria*, *Luzula multiflora* and *Polygala alpestris* (Table 2) and by the significant prominence of the species belonging to the classes Koelerio-Corynephoretea and Festuco-Brometea (Table 1). Moreover, the diagnostic species of Caricetea curvulae only slightly prevail on those of Nardetea strictae. On this basis, the community can be recognised as an independent subassociation, for which we propose the name Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae Gennai, Foggi, Viciani, Carbognani et Tomaselli subass. *nova hoc loco* holotypus rel. 64 in Table 6 and Electronic Appendix 3: VF-NA lm. Cluster C is fairly variable in its floristics, as reflected in the dendrogram (Fig. 2). Relevés from 13 to 66 represent the typical variant of the subassociation, whereas a minority of relevés (from 51 to 58) can be assigned to a variant differentiated by *Calluna vulgaris*, *Dianthus sylvestris*, *Hieracium pilosella*, *Juniperus communis* subsp. *alpina*, *Plantago maritima* subsp. *serpentina* and *Potentilla erecta*, named *Potentilla erecta*-variant (Electronic Appendix 4). The occurrence of dwarf shrubs in this list indicates a possible gradual progress to a dwarf shrub vegetation. The Violo ferrarinii-Nardetum strictae luzuletosum multiflorae occurs on both northern and southern slopes of the Tuscan-Emilian Apennines and occasionally in the Apuan Alps over acidic substrates.

Cluster D is composed by 17 relevés where vegetation is dominated by grasses, notably *Nardus stricta* and *Festuca rubra* subsp. *commutata*, with smaller amounts of *Phleum rhaeticum*. The commonest dicotyledonous associates are *Trifolium pratense*, *Alchemilla* gr. *vulgaris*, *Lotus corniculatus* and *Sagina glabra* (Electronic Appendix 5). The cluster is differentiated by a bulk of Molinio-Arrhenatheretea species (*Alchemilla* gr. *vulgaris*, *Lotus corniculatus*, *Phleum rhaeticum*, *Trifolium pratense*), by *Botrychium lunaria*, *Gentiana verna*, *Ranunculus polllinensis* and *Viola reichenbachiana* and by the significant prominence of Molinio-Arrhenatheretea and Elyno-Seslerietea species (Table 1). Moreover, the Nardetea species are slightly prevailing on the species belonging to Caricetea curvulae. As a consequence, we treated it as a new independent subassociation named Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici Gennai, Foggi, Viciani, Carbognani et Tomaselli subass. *nova hoc loco* holotypus rel. 105 in Table 6 and Electronic Appendix 4: VF-NA pr. Subassociation is almost wholly confined to the calcareous areas of the Apuan Alps, with some isolated sites in the Tuscan-Emilian Apennines over calcium-rich sandstone bedrocks. Its peculiar floristic assemblage characterized by the occurrence of mildly basiphilous and/or of more nutrient demanding species can be depending on the ground irrigated by run-off from calcareous rocks and/or from resting from grazing and pastures abandonment.

Ecological characterization of vegetation types

The RDA ordination (Fig. 3) shows a clear separation of the five vegetation types. In particular, the stands of the Carlino caulescentis-Nardetum strictae are located in a separate position towards the left margin of the ordination space. Their position reflects a marked floristic and ecologic independence with respect to the stands of the Violo ferrarinii-Nardetum strictae as a whole.

All the explanatory variables are significantly correlated with the vegetation types, with altitude and light together explaining more than 50 % of the explained variance (Table 3). Collinearity among explanatory variables was found negligible (maximum variance inflation factors: 1.69 for Elevation), and forward selection showed that all the considered factors were significantly related to the floristic variation (minimum: $P = 0.001$ for Soil Reaction). Permutation tests on ordinations with ecological indicators, performed to analyse the bias due to the "similarity issue" (Zelený & Schaffers 2012), indicated that the ecological indicators were significantly related to the canonical axes, also after taking into account the effect of floristic compositional similarity (minimum: $P = 0.002$ for Continentality).

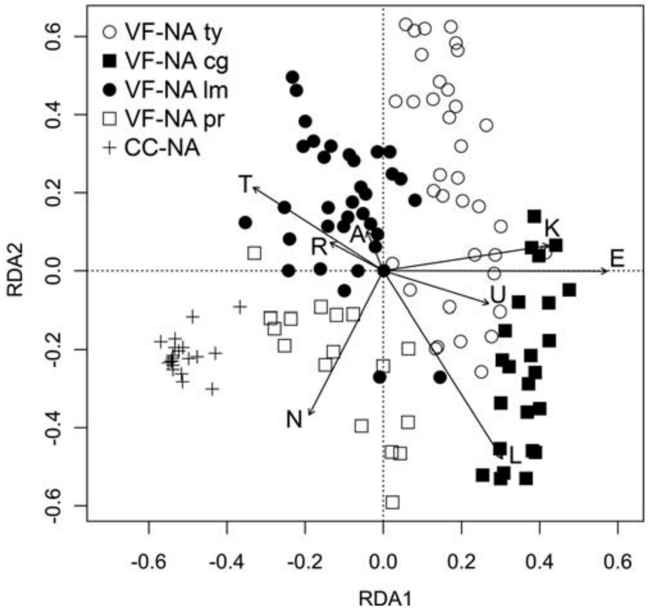


Fig. 3. RDA ordination diagram of the different subassociations of the Violo ferrarinii-Nardetum strictae and the Carlino caulescentis-Nardetum strictae. A = Aspect; E = Elevation; K = Continentality; L = Light; N = Nitrogen; R = Soil Reaction; T = Temperature; U = Moisture, VF-NA cg = Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis; VF-NA lm = Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae; VF-NA pr = Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici.

Ordination diagram (Fig. 3) shows the correlations of the explanatory variables with the first two ordination axes. Elevation is positively correlated with the first ordination axis. Also continentality and, more weakly, moisture are positively correlated with the first axis. Both these parameters increase with altitude: continentality for the higher incidence of the species belonging to the class Caricetea curvulae and moisture as a consequence of the longer persistence of snow above ground. Temperature is negatively correlated with the first axis, but this correlation is not precisely opposite with respect to that of elevation, because temperature is also conditioned by aspect.

The second axis of RDA is correlated mostly to average light intensity and soil nutrient content. Both correlations are negative. The light gradient is presumably determined by the incidence of ericaceous sub-shrubs that is higher in the stands of the Violo ferrarinii-Nardetum strictae typicum and of the subassociation luzuletosum multiflorae, mostly occurring at the positive side of the axis. Soil nutrient content shows a similar pattern, but in this case the closest relation is with the stands of the subassociation phleetosum rhaetici more rich in Molinio-Arrhenatheretea-species and having a more base-rich underlying soils owing to the calcareous parent material.

Since elevation is largely the most significant explanatory variable, the altitudinal gradient of the *Nardus* grasslands in the northern Apennines was analysed also directly and shown in Figure 4. The stands of the Carlino caulescentis-Nardetum strictae are confined to the lowest extreme of the altitudinal gradient with a median value just lower than 1500 m. They are significantly separated from those of the Violo ferrarinii-Nardetum strictae as a whole, whose altitudinal range is considerably wider, comprised between 1500 and 2030 m (with an outlying

Table 3. Significant explanatory variables obtained after the forward selection procedure. Adj-R^2= adjusted R^2; *F* = the *F*-statistic; *P* = the *P*-value statistic; PEV = portion of the explained variance in percentage.

	Adj-R^2	*F*	*P*	PEV (%)
Elevation (E)	0.0864	13.58	0.001	36.3
Light (L)	0.0484	8.39	0.001	20.4
Continentality (K)	0.0393	7.24	0.001	16.5
Nitrogen (N)	0.0135	3.17	0.001	5.7
Moisture (U)	0.0143	3.31	0.001	6.0
Temperature (T)	0.0133	3.18	0.001	5.6
Aspect (A)	0.0124	3.04	0.001	5.2
Soil Reaction (R)	0.0102	2.70	0.001	4.3

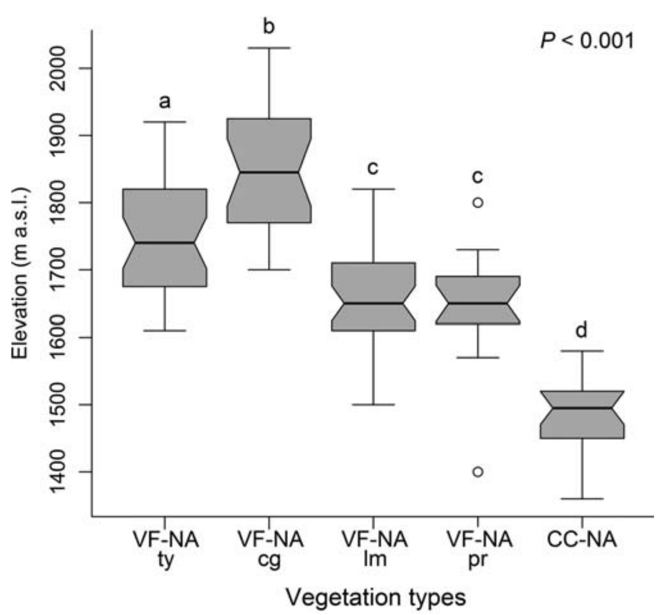


Fig. 4. Box-plot diagrams for the altitudinal distribution of the different subassociations of the Violo ferrarinii-Nardetum strictae and the Carlino caulescentis-Nardetum strictae. VF-NA cg = Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis; VF-NA lm = Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae; VF-NA pr = Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici. The letters show cross significativity. *P*-values refer to Kruskal-Wallis test, whereas different letters indicate significant differences (Wilcoxon test, $P < 0.05$) between subassociations.

sample at 1400 m). Within the Violo ferrarinii-Nardetum strictae the typical subassociation and the subassociation crepidetosum glabrescentis are confined to higher altitudes, from the high-montane to the subalpine vegetation belt (from around 1600 to 2030 m of altitude). The Violo ferrarinii-Nardetum strictae typicum is concentrated between 1610 and 1920 m. It significantly differs from the subassociation crepidetosum glabrescentis that is characteristically found only above 1700 m. The subassociations luzuletosum multiflorae and phleetosum rhaetici are significantly separated from the previous ones, but not significantly among themselves. Both subassociations are, in fact, centered in the montane vegetation belt around an altitude of 1650 m. The subassociation luzuletosum multiflorae shows, however, a wider altitudinal range (from 1500 to 1820 m). Anyway, the two subassociations seems to be more clearly differentiated by the soil nutrient content, as suggested by the different position of respective stands along the second axis of RDA (Fig. 3).

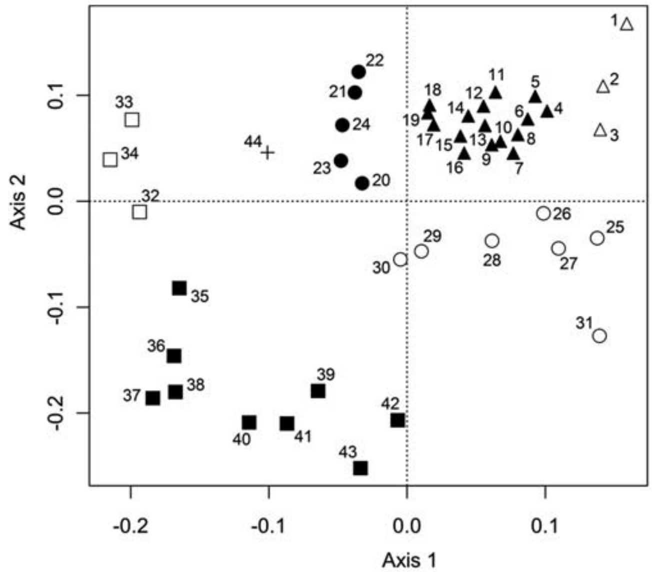


Fig. 5. NMDS ordination diagram for the 44 synoptic tables of *Nardus*-rich grasslands from the Alps, the Apennines and the Carpathians (one table). Δ = Group A; ▲ = Group B; ● = Group C; ○ = Group D; □ = Group E; ■ = Group F; + = Nardo-Agrostion tenuis. Groups and column numbers as in Table 4. Details on the geographic distribution of the groups are in Appendix 3.

Eco-geographical gradients

NMDS calculation on the set of synoptic tables (Table 4) produced a stable solution after 40 runs with a stress of 12.2. The ordination diagram (Fig. 5) shows that six main groups of *Nardus* communities can be clearly distinguished regarding their position within the ordination space defined by the two first ordination axes. Two groups (A and B), comprising exclusively *Nardus* communities from the Alps, have positive values on both axes. Group A brings together three tables comprising high-altitude *Nardus* communities from the south-eastern Alps, while group B includes those ranging from the high-montane to the subalpine vegetation belt of the northern and south-eastern Alps. Two smaller groups and an isolated intermediate table can be distinguished at the upper left side of the ordination space. Among them, group C includes five tables of typically montane *Nardus* grasslands from south-eastern Alps (three tables) and from north-eastern Alps and Jura (one table each). Group E, lying at the extreme left side of the diagram, comprises three relevés groups from northern and central Apennines (Pratomagno and Sibillini Mountains). The isolated table intermediate between groups C and E is the original table of Sillinger from the Carpathians on which the alliance Nardo-Agrostion tenuis was established. In the lower half of the ordination space two groups, lying respectively at the right and the left side, are clearly distinguished. Group D is geographically heterogeneous including tables from both south-western Alps and northern Apennines, whereas group F includes only tables from central and southern Apennines. From the syntaxonomical viewpoint, groups A, B, C and D include synoptic tables corresponding to the associations Sieversio montanae-Nardetum strictae Lüdi 1948 (see Appendix 1 for details on nomenclatural correction) from the Alps, Nigritello cornelianae-Nardetum strictae Barbero 1970 and Aveno versicoloris-Nardetum strictae Oberd. (1950) 1957, all belonging to the alliance Nardion strictae. Groups E includes two associations: Carlino caulescentis-Nardetum strictae Viciani et Gabellini 2000 and Nardetum apenninicum Cortini Pedrotti et al. 1973, both likely ascribable to the Nardo-Agrostion tenuis. Finally, group F comprises all the associations belonging to the alliance Ranunculo pollinensis-Nardion strictae Bonin 1972.

The compositional differences among the six groups seem to be related to both different geographical and altitudinal distributions. The assumption is supported by the results of the analyses based on the distribution of chorotypes and phytosociological classes (Table 5). The species with arctic-alpine and circumboreal range and the central-southern European orophytes have their highest occurrence in Group A and B including *Nardus* communities from the high-montane to the low-alpine vegetation belt of the Alps. These chorotypes markedly decrease in the central and southern Apennines (group E and F), where, conversely, Mediterranean and Endemic species and Mediterranean orophytes considerably increase. The Eurosiberian and Eurasian species have their highest incidence within the montane *Nardus* communities of both the Alps and northern and central Apennines. A similar occurrence is showed by the species belonging to the Molinio-Arrhenatheretea class. Among the phyto-

Table 4. Synoptic table of Nardus-rich grasslands from the Alps, Apennines and Carpatians. Data source are in Appendix 3. In the bottom of the table are reported the rare species with less than three presences.

NMDS Group		A									B											C						D					E							F					
Column numbers.	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
Number of relevés for each column	6	9	5	6	10	14	19	18	14	13	7	11	7	10	8	12	17	12	21	20	16	11	25	13	29	16	7	19	24	17	24	20	16	15	8	22	9	7	10	19	6	5	11	11
Nardus stricta	100	100	100	100	100	100	100	100	100	100	100	82	100	100	100	100	88	92	100	100	100	100	100	100	100	100	100	100	100	94	100	100	100	100	100	100	100	100	100	89	100	100	100	100
Nardion strictae																																												
Potentilla aurea	.	100	100	33	70	86	84	100	41	85	57	82	100	60	25	100	88	83	90	30	75	82	56	62	.	.	.	87	25	35	33	.	.	53	.	.	.	.	.	.	.	.	.	100
Gentiana acaulis	.	100	60	83	80	71	58	61	94	100	100	82	100	70	63	58	71	50	.	20	13	91	36	.	31	88	71	.	25	24	4	35	.	.	.	.	.	.	.	.	.	.	.	.
Geum montanum	.	100	100	83	70	100	100	83	100	100	100	9	100	90	75	17	35	25	81	15	.	27	.	.	83	44	100	100	96	24	75	.	.	.	.	.	.	.	.	.	.	.	.	27
Leontodon helveticus	50	56	100	83	90	93	21	94	59	77	14	100	100	70	75	92	41	50	29	.	13	.	.	.	66	.	14	73	25	24	4	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula barbata	100	78	60	83	100	86	74	39	71	69	71	91	77	90	88	50	65	42	.	20	25	73	.	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solidago virgaurea subsp. alpestris	17	.	20	.	80	93	89	22	18	15	43	72	.	50	.	8	53	50	.	10	6	9	24	15	.	.	.	.	.	.	.	.	.	.	.	5	.	.	10	.	.	.	.	.
Pseudorchis albida	33	22	.	33	90	29	16	.	41	15	43	.	38	50	50	67	18	33	24	.	6	.	.	23	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18
Ligusticum mutellina	.	.	60	67	70	.	16	61	.	46	.	64	85	20	25	42	6	33	52	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago alpina	.	.	.	.	70	.	.	.	.	.	71	55	100	.	50	33	.	25	.	.	50	.	.	.	83	100	100	53	4	6	75	.	.	.	.	.	.	.	.	.	.	.	.	.
Ajuga pyramidalis	.	.	.	33	.	7	.	22	.	54	57	.	.	10	.	8	29	17	5	.	.	.	.	15	17	19	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula sudetica	.	67	100	67	80	100	.	78	59	62	.	.	.	80	63	.	53	.	.	.	.	.	.	54	.	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Trifolium alpinum	.	.	100	.	.	.	74	100	.	100	100	.	.	.	13	25	.	.	.	.	.	.	.	.	79	100	86	53	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis tuberosa	83	22	.	.	.	.	.	.	.	.	43	.	.	.	.	17	.	.	.	.	.	18	.	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viola ferrarini	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	47	54	6	12	.	.	.	.	.	.	.	.	.	.	.	.	.
Caricetalia and Caricetea curvulae																																												
Euphrasia minima	83	78	100	67	70	7	79	67	18	62	86	91	92	20	.	25	6	33	14	5	6	.	.	.	.	13	14	40	.	18	4	.	.	.	.	.	.	.	.	.	.	.	.	.
Agrostis rupestris	100	56	80	67	70	43	21	94	6	69	29	55	62	.	13	17	6	8	24	.	.	.	.	.	45	.	57	7	4	24	12	.	.	.	.	.	.	.	.	.	.	.	.	.
Botrychium lunaria	.	11	80	.	30	.	.	6	6	.	14	.	15	.	.	.	47	.	.	5	.	9	.	.	48	44	29	.	.	24	.	.	.	.	.	.	11	.	20	26	33	.	9	27
Helictotrichon versicolor	100	100	80	.	100	93	74	11	29	8	86	91	.	.	13	17	18	.	.	5	.	.	.	.	.	19	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa variegata	.	.	.	.	.	7	.	.	6	8	14	.	.	.	.	.	6	.	.	.	.	45	.	.	41	44	14	.	.	.	.	.	6	80	63	68	100	100	60	.	.	.	45	.
Phyteuma betonicifolium	.	.	20	17	40	.	26	56	.	69	57	9	.	.	88	17	.	33	.	10	13	18	.	.	.	.	.	60	25	.	42	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypochoeris uniflora	33	11	40	.	60	14	11	.	6	8	71	18	.	20	.	17	24	.	.	.	.	36	.	.	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Phyteuma hemisphaericum	67	89	100	83	10	71	74	89	64	92	43	.	.	10	.	33	24	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula spicata subsp. mirabilis	.	.	40	.	.	36	.	39	.	46	.	.	15	20	.	.	24	8	.	.	.	9	12	.	41	.	57	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica bellidioides	67	67	60	.	20	14	42	22	12	38	29	.	.	.	.	.	24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus trifidus	.	33	80	.	.	71	42	.	24	8	.	.	.	.	.	.	12	.	.	.	.	.	.	.	10	.	.	7	.	.	12	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium alpinum	.	11	40	.	100	14	.	56	.	38	.	55	.	.	.	.	6	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pulsatilla alpina s.l.	.	67	80	.	10	29	47	.	.	.	71	.	.	20	.	8	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Centaurea uniflora subsp. nervosa	33	.	.	.	.	.	.	.	12	.	.	.	.	10	25	8	6	.	.	.	.	.	.	.	.	.	.	.	8	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crepis conyzifolia	.	.	.	.	30	7	.	.	.	.	.	.	.	10	38	.	29	25	.	.	.	.	.	.	3	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana punctata	.	100	.	.	80	64	.	.	6	.	.	64	.	.	13	.	.	50	.	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helictotrichon versicolor subsp. praetutianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	18	22	.	20	42	17	20	.	.
Alchemilla gr. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	.	.	.	.	.	.	.	.	.	.	86	53	83	35	58	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca gr. varia	100	78	.	.	.	.	.	.	6	.	.	.	.	.	.	8	.	.	.	5	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium angustifolium	.	.	.	.	20	7	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38	19	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucanthemopsis alpina	.	.	60	33	10	.	11	67	.	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula lutea	.	11	.	.	.	.	16	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	34	.	43	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agrostis schraderana	17	.	.	33	.	7	.	.	.	.	.	9	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia alpina	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	.	.	.	.	.	.	.	7	4	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium alpicola	.	.	.	.	.	36	.	.	.	.	.	.	.	40	.	.	6	.	.	.	.	.	.	.	.	.	.	7	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica fruticans	.	.	40	.	.	.	21	17	.	15	.	.	.	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viola calcarata (incl. subsp. cavillieri)	.	.	.	.	.	.	.	.	.	.	.	.	100	.	38	.	.	.	.	.	.	.	56	.	69	.	57	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla glaucescens	.	.	.	.	.	7	.	.	.	.	.	.	.	20	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	.	.	.	.	.	.	.	.
Festuca halleri	.	78	80	.	.	.	42	.	.	.	57	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca paniculata	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	14	.	.	.	.	.	.	.	.	5	.	.	20	.	.	.	.	.
Hieracium glanduliferum	.	22	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium hoppeanum	.	.	.	.	40	.	.	6	6	23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium intybaceum	.	.	.	.	.	.	16	6	.	8	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla grandiflora	.	.	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	31	69	86	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pulsatila vernalis	.	44	.	.	.	.	16	6	.	.	57	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nardetea strictae																																												
Luzula multiflora	.	.	.	17	40	43	53	33	88	38	100	36	100	60	38	83	53	83	62	60	25	91	80	85	48	38	43	60	83	71	.	.	94	100	50	5	.	.	.	11	33	.	18	100
Hieracium pilosella	.	.	60	17	.	.	74	33	29	54	100	9	.	10	.	17	29	33	10	70	50	27	48	69	.	.	.	13	12	24	.	80	56	67	38	95	100	57	10	79	67	60	.	82
Potentilla erecta	67	.	.	83	30	86	26	100	59	85	86	27	38	100	75	83	53	75	43	90	94	91	68	100	.	.	.	40	17	35	.	70	100	67	.	.	.	.	.	.	.	.	.	.
Antennaria dioica	.	11	100	.	20	29	53	61	29	85	86	.	.	30	38	8	18	58	.	.	.	45	40	8	31	19	57	20	4	29	.	30	.	.	.	.	.	.	.	.	.	.	.	45
Arnica montana	83	78	40	67	100	93	79	78	71	62	100	72	46	100	50	42	88	58	.	10	56	100	.	62	48	94	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Coeloglossum viride	33	22	.	50	50	36	.	6	29	.	43	9	15	30	25	8	18	8	19	.	6	55	12	.	.	19	.	.	.	6	.	.	.	.	13	.	.	.	.	.	.	.	.	9
Carex pallescens	.	.	.	83	40	43	.	94	.	15	29	45	23	70	50	58	29	75	33	.	88	18	28	77	.	.	.	13	4	.	.	.	44	.	.	.	.	.	.	.	.	.	.	.
Hieracium lactucella	.	.	60	.	10	21	5	78	41	77	71	36	62	20	75	33	29	25	14	10	19	36	.	.	38	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex leporina	.	.	.	.	.	7	.	.	6	.	.	.	.	10	.	17	6	.	10	10	31	.	.	31	.	.	14	20	12	6	12	.	13	7	.	.	.	.	.	.	.	.	.	18

Table 4. cont.

NMDS Group		A										B										C						D					E							F				
Column numbers.	**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**
Number of relevés for each column	**6**	**9**	**5**	**6**	**10**	**14**	**19**	**18**	**14**	**13**	**7**	**11**	**7**	**10**	**8**	**12**	**17**	**12**	**21**	**20**	**16**	**11**	**25**	**13**	**29**	**16**	**7**	**19**	**24**	**17**	**24**	**20**	**16**	**15**	**8**	**22**	**9**	**7**	**10**	**19**	**6**	**5**	**11**	**11**
Veronica officinalis	.	.	.	.	.	7	5	6	.	.	.	.	.	.	38	8	.	33	.	50	19	18	64	77	.	.	.	.	21	12	.	70	.	.	38	.	11	.	.	.	.	.	.	100
Dianthus deltoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	29	18	.	.	38	60	50	55	67	100	20	26	83	.	55	9
Gnaphalium sylvaticum	.	.	.	.	.	.	.	22	.	46	.	18	.	.	.	8	.	.	.	20	19	.	60	54	.	13	.	.	.	6	.	10	.	.	.	14	33	.	.	.	.	.	.	55
Hypericum maculatum	.	.	.	.	10	7	.	11	12	15	.	.	.	30	38	8	47	25	29	.	.	.	68	92	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36
Carex pilulifera	.	.	20	.	.	7	.	39	.	31	57	18	.	.	38	25	.	17	.	.	31	.	28	.	.	.	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27
Danthonia decumbens	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	12	58	.	15	19	.	8	.	.	.	.	.	4	.	.	70	100	100	.	.	.	.	.	.	17	.	.	18
Galium pumilum	.	.	.	.	.	.	.	.	.	.	71	.	31	40	63	8	41	.	.	.	.	55	44	69	.	31	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18
Luzula campestris	.	.	.	.	.	7	.	.	.	.	.	64	.	.	.	.	6	.	10	.	63	.	.	8	.	.	.	.	.	.	.	100	.	.	50	50	56	43	10	.	.	.	.	.
Gentiana campestris	.	.	.	17	.	.	.	22	.	31	.	18	46	.	.	8	.	.	.	.	.	.	16	.	.	19	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.
Ranunculus pollinensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	35	.	.	.	.	25	91	78	.	90	74	33	20	36	.
Meum athamanticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	62	50	71	.	4	18	.	.	.	60	.	.	.	.	.	.	17	.	36	.
Polygala vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	.	6	.	4	.	.	.	.	.	.	.	.	30	25	93	13	.	.	.	.	.	.	.	.	9
Viola canina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24	8	.	.	.	9	20	.	.	.	.	.	.	.	.	20	38	80	.	.	.	.	.	.	.	.	.	45
Ranunculus apenninus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	8	6	4	.	.	.	13	.	.	.	.	5	.	80	.	.
Viola eugeniae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	65	6	67	.	5	.	.	60	58	.	60	.	.
Crepis aurea subsp. glabrescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	4	29	87	.	.	.	.	.	.	.	.	.	33	.	36	.
Potentilla rigoana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	100	86	.	84	100	.	45	.
Ajuga tenorii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	44	29	.	32	.	.	9	.
Luzula italica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	.	.	90	79	.	100	.	.
Phyteuma zahlbruckneri	.	.	.	.	.	7	.	.	6	.	.	.	.	.	.	.	12	.	.	.	.	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polygala angelisii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	.	.	40	.	50	.	64	.
Taraxacum apenninum (group)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	14	.	21	.	20	.	.
Trifolium repens subsp. prostratum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	44	.	50	.	.	60	9	.
Molinio-Arrhenatheretea																																												
Poa alpina	.	56	80	67	10	64	62	94	59	92	43	55	54	50	50	50	71	8	48	70	56	55	.	69	62	75	100	47	62	24	100	.	.	7	50	5	78	29	70	68	67	100	36	45
Lotus corniculatus	.	78	20	.	.	.	42	44	29	100	100	.	92	10	25	17	24	33	43	55	.	91	48	54	.	100	71	13	37	65	4	100	6	60	88	95	11	.	50	58	100	.	36	91
Phleum rhaeticum	.	11	40	83	30	50	21	67	18	92	.	55	31	80	63	67	41	17	48	15	38	91	64	54	59	69	57	67	25	94	33	.	.	.	.	.	.	14	40	.	.	40	.	55
Crocus albiflorus	.	.	.	.	.	7	11	6	24	15	71	18	100	20	13	67	41	8	.	20	31	9	96	54	10	.	86	.	8	6	4	15	19	13	25	.	67	.	.	47	.	100	.	.
Agrostis capillaris	.	.	.	.	60	7	11	56	.	62	.	64	100	30	13	58	53	58	24	65	44	.	92	92	10	.	.	7	12	18	.	65	.	.	75	100	44	100	.	16	.	20	.	100
Trifolium pratense	.	.	.	.	10	.	.	28	53	38	29	55	100	20	38	8	71	17	43	.	63	64	20	100	.	.	.	27	33	76	17	15	69	100	50	55	.	.	.	.	.	.	.	82
Deschampsia caespitosa	50	22	20	83	10	29	21	17	.	8	.	55	.	10	.	33	29	42	76	20	75	27	48	69	.	.	.	60	4	.	12	.	50	7	.	.	.	.	.	.	.	.	.	9
Leontodon hispidus	.	.	.	.	40	14	53	6	6	.	.	72	100	90	.	17	88	50	57	40	81	55	.	38	.	44	29	.	.	12	.	10	56	93	25	.	.	.	.	11	17	.	.	18
Achillea millefolium	.	.	20	.	.	7	11	6	.	31	.	.	.	10	13	8	59	.	19	55	31	.	56	85	31	50	29	.	4	24	.	30	13	93	50	9	.	.	.	.	.	.	.	73
Cerastium holosteoides	.	11	.	.	30	21	5	6	12	.	.	45	23	40	25	.	47	.	19	15	19	27	40	85	.	25	.	7	12	6	.	30	88	87	.	.	.	.	.	.	.	.	.	82
Alchemilla gr. vulgaris	.	11	80	33	.	7	11	50	24	54	.	45	92	10	75	.	59	.	.	15	75	82	20	46	.	13	43	.	.	71	.	15	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium repens	.	11	.	67	.	.	26	11	.	23	57	.	.	30	.	.	65	.	5	45	56	73	20	77	28	.	.	13	.	.	.	20	13	40	.	32	.	.	.	21	.	.	.	45
Leucanthemum gr. vulgare	.	11	.	.	30	.	.	.	.	8	71	.	.	20	25	8	24	17	.	15	38	64	.	15	.	44	.	.	.	.	.	.	19	93	25	.	.	.	.	.	.	.	.	45
Crepis aurea	.	22	20	.	20	21	.	56	12	38	.	27	100	20	75	.	12	25	38	5	75	.	.	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prunella vulgaris	.	.	.	.	.	.	.	11	.	31	.	.	8	20	38	8	41	.	14	50	44	36	8	62	.	.	.	.	.	.	.	.	.	20	.	.	.	.	.	.	.	.	.	45
Ajuga reptans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	.	8	.	5	19	64	16	.	.	.	.	7	12	6	.	45	13	7	.	5	.	.	.	.	.	.	.	.
Bistorta officinalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	42	.	.	.	.	13	36	8	.	24	25	86	53	42	6	.	.	100	93	.	.	.	.	10	.	.	.	.	.
Rumex acetosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	18	.	.	.	19	36	4	.	.	6	.	.	.	.	.	10	100	100	63	.	44	71	.	.	.	.	.	9
Trollius europaeus	.	78	.	.	.	14	.	.	.	.	.	36	.	.	63	.	35	8	5	5	13	82	8	23	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stellaria garminea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	12	.	5	40	.	9	28	38	.	.	.	.	4	12	.	5	.	38	.	.	.	.	.	.	.	.	.	91
Gymnadenia conopsea	.	.	.	.	.	29	.	.	41	.	71	9	.	80	.	.	29	.	.	.	.	82	12	.	7	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Taraxacum officinale	.	.	.	.	.	.	5	.	.	.	.	.	.	.	13	.	24	.	.	.	25	9	.	15	17	.	.	7	8	6	.	.	.	.	.	.	11	.	.	.	.	.	.	.
Trifolium badium	.	33	.	.	.	.	.	6	.	.	14	.	8	10	.	.	6	.	.	.	6	.	.	8	.	.	29	.	.	.	.	.	94	27	.	.	.	.	.	.	.	.	.	.
Carum carvi	.	.	.	.	.	.	5	.	6	.	14	.	.	.	.	.	12	.	.	.	19	55	32	38	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Ranunculus acris	.	22	.	.	.	.	.	.	.	15	.	.	.	20	.	.	.	.	5	.	38	91	.	85	.	.	.	.	.	.	.	.	94	73	.	.	.	.	.	.	.	.	.	36
Leontodon autumnalis	.	.	.	.	.	.	.	11	.	.	.	.	.	20	.	.	.	.	.	25	19	.	.	.	.	.	14	.	.	.	.	.	38	20	25	.	.	.	.	.	.	.	.	9
Ranunculus tuberosus	.	.	.	.	10	.	.	.	.	.	.	45	.	20	.	.	59	17	19	.	75	.	32	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex nebroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	6	4	.	.	.	.	32	.	14	60	21	.	20	45	.
Cynosurus cristatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	31	9	.	.	.	.	.	.	.	.	.	5	25	67	38	.	.	.	.	.	.	.	.	18
Euphrasia rostkoviana	.	.	.	.	.	.	16	.	12	.	.	.	.	.	.	.	.	8	.	35	19	.	20	62	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	55
Plantago lanceolata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18	.	.	.	13	91	12	46	.	.	.	.	.	.	.	.	.	.	13	.	22	.	.	.	.	.	.	18
Sagina glabra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24	.	57	67	25	65	25	.	.	.	.	.	.	.	.	.	.	20	18	.
Trifolium pratense subsp. nivale	.	44	.	.	.	14	16	.	.	.	.	.	.	10	.	.	.	.	.	65	.	.	.	.	48	75	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthriscus sylvestris	.	.	.	.	.	.	.	6	.	15	.	.	.	.	.	8	6	.	.	5	6	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium pratense subsp. semipurpureum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	71	90	47	83	20	36	.
Agrostis stolonifera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	18	.	.	.	38	.	.	.	.	.	.	13	40	.	.	.	.	.	.	.	.	18	.
Centaurea jacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12	.	.	15	6	.	.	8	.	.	.	.	.	.	.	.	31	40	.	.	.	.	.	.	.	.	.	.
Lathyrus pratensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	9	12	.	.	19	.	.	.	.	.	.	56	80	.	.	.	.	.	.	.	.	.	.
Poa supina	.	.	20	.	.	.	.	11	.	15	.	9	.	.	.	17	.	.	.	.	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhinanthus alectorolophus	.	.	.	.	10	.	.	.	.	.	71	.	.	.	.	8	.	17	.	.	6	.	.	.	.	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4. cont.

NMDS Group		A										B										C						D					E						F					
Column numbers.	**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**
Number of relevés for each column	**6**	**9**	**5**	**6**	**10**	**14**	**19**	**18**	**14**	**13**	**7**	**11**	**7**	**10**	**8**	**12**	**17**	**12**	**21**	**20**	**16**	**11**	**25**	**13**	**29**	**16**	**7**	**19**	**24**	**17**	**24**	**20**	**16**	**15**	**8**	**22**	**9**	**7**	**10**	**19**	**6**	**5**	**11**	**11**
Bellis perennis	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	38	.	.	23	.	.	.	.	.	.	.	.	.	.	38	.	22	.	.	.	.	.	.	.
Euphrasia picta	.	.	.	.	.	36	.	.	.	.	.	.	.	50	.	.	47	.	19	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Knautia arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	5	.	9	.	.	.	.	.	.	.	.	.	.	.	73	.	.	.	.	.	.	.	.	.	9
Narcissus poeticus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	63	67	25	.	.	.	.	11	.	.	.	.
Poa trivialis	.	.	.	.	.	.	.	.	.	8	.	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	20	25	.	.	.	.	.	.	.	.	.
Sanguisorba officinalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	13	4	.	.	.	100	67	.	.	.	.	.	.	.	.	.	.
Astrantia major	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	25	27	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Colchicum lusitanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	13	.	9	11	.	.	.	.	.	.	.
Dactylis glomerata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	19	18	.	23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Genista tinctoria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	35	.	.	.	.	.	.	.	7	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Molinia coerulea	17	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Primula elatior (incl. subsp. intricata)	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	5	.	.	82	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18
Veronica serpyllifolia	.	.	.	.	.	.	.	22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	71	.	.	.	.	.	.	.	.	.	.	14	.	.	.	.	.	.
Vicia cracca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	50	80	.	.	.	.	.	.	.	.	.	.
Festuco-Brometea																																												
Carlina acaulis subsp. caulescens	17	11	20	.	10	14	42	.	24	23	.	18	.	20	13	8	53	50	5	40	31	64	36	69	14	63	57	20	42	12	.	90	.	.	38	73	56	14	10	11	.	20	.	36
Briza media	.	.	20	.	.	7	.	.	12	.	86	.	.	10	50	.	12	17	19	.	25	55	16	23	.	50	.	.	.	.	.	.	31	100	38	.	.	.	.	.	.	.	.	45
Carex caryophyllea	.	.	.	.	.	.	.	6	6	.	.	.	.	.	.	.	.	.	5	.	25	18	16	15	.	.	.	.	4	.	.	60	.	.	50	64	67	.	60	11	50	.	.	18
Cerastium arvense subsp. suffruticosum	.	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	31	100	7	21	6	.	45	.	73	75	86	100	71	80	53	.	40	.	.
Galium verum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	9	16	8	.	69	.	.	.	.	.	10	81	88	100	.	67	86	.	26	.	20	.	.
Dactylorhiza sambucina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	12	.	.	.	.	18	12	8	28	.	.	.	12	.	.	5	.	.	38	.	.	.	.	16	.	.	9	.
Plantago media	.	.	.	.	.	.	.	.	6	.	29	.	.	.	.	8	12	.	5	10	.	45	.	.	.	31	.	.	.	.	.	.	.	47	25	.	.	.	.	.	.	.	.	36
Euphrasia stricta	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	5	75	87	.	32	.	.	90	.	83	.	27	.
Hippocrepis comosa	.	.	.	.	.	.	.	.	.	.	43	.	.	.	.	.	.	.	5	.	6	18	.	8	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	32	50	.	18	.
Trifolium montanum	.	.	.	.	.	.	.	.	.	38	.	.	.	.	.	.	6	.	.	.	13	.	8	8	.	94	.	.	.	.	.	.	.	.	.	5	.	.	20	.	.	.	.	.
Armeria canescens (incl. subsp. gracilis)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	27	25	.	.	29	.	42	50	.	45	.
Gentiana germanica	.	.	.	.	.	.	53	.	.	.	29	9	.	.	.	.	24	.	5	5	.	.	.	.	.	.	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Linum catharticum	.	.	.	.	.	.	.	.	.	15	.	.	.	.	.	.	12	8	.	.	6	.	.	15	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18
Pimpinella saxifraga (incl. P. alpestris)	.	.	.	.	.	7	.	.	47	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	7	46	12	.	.	.	.	.	.	.	.	.	.	.	.	.	55
Silene vulgaris	.	.	.	.	.	.	11	17	.	8	.	9	.	20	.	8	.	.	.	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia cyparissias	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9	16	15	.	.	.	.	.	6	.	.	.	.	.	.	56	.	.	.	.	20	.	.
Thymus longicaulis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	86	56	14	30	47	.	.	.	.
Campanula rotundifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	6	8	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	7	.	.	.	.	.	.	.	.	.	.
Stachys tymphaea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	11	.	10	.	.	20	9	.
Verbascum longifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	64	67	57	10	21	.	.	.	.
Asperula cynanchica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18	.	14	10	37	.	.	.	.
Brachypodium gr. pinnatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	13	18	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex flacca	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.	.	.	.	.	38	.	8	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex montana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	12	.	.	.	.	55	.	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium acaule	.	.	.	.	.	.	.	.	.	.	86	.	.	.	.	.	.	.	.	.	19	.	16	.	.	.	.	.	.	.	.	.	.	.	.	.	33	.	.	.	.	.	.	.
Koeleria pyramidata	.	.	60	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	18	36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thymus pulegioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28	.	.	.	.	.	.	.	.	60	.	53	.	.	.	.	.	.	.	.	.	100
Elyno-Seslerietea																																												
Galium anisophyllum	.	.	60	17	10	7	5	50	53	92	.	27	.	10	.	.	29	.	29	.	44	.	.	.	.	.	.	.	50	6	4	.	.	.	.	.	.	.	.	.	33	40	27	.
Trifolium thalii	.	33	.	.	0	21	.	28	.	23	.	9	38	30	25	.	6	8	.	.	.	.	.	.	41	.	71	7	4	6	4	.	.	.	.	.	.	.	.	21	.	60	.	.
Nigritella gr. nigra	.	22	40	.	30	14	16	.	29	.	43	9	8	.	25	.	12	.	.	.	6	64	16	15	17	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago atrata	.	.	.	.	.	.	.	28	.	15	.	.	46	.	13	.	.	8	.	.	44	18	16	31	.	.	.	.	.	.	.	.	.	.	.	32	22	.	100	63	50	40	45	.
Polygala alpestris	.	.	.	.	.	.	5	.	.	8	86	.	15	.	.	.	35	.	.	45	13	64	12	31	7	13	.	7	58	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.
Carduus carlinaefolius (incl. C. defloratus)	.	.	.	.	.	.	.	.	41	.	.	.	.	.	.	.	6	8	5	5	19	73	4	.	31	.	29	.	.	6	.	.	.	.	.	14	.	.	.	21	33	.	.	.
Thesium alpinum	.	22	.	33	.	.	21	6	.	15	71	9	15	.	.	8	24	25	5	.	.	.	.	15	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana lutea	17	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	17	.	.	25	27	68	.	.	.	.	.	.	.	.	.	.	60	38	5	.	.	80	21	.	.	18	.
Phyteuma orbiculare	.	.	.	.	.	.	.	.	.	.	.	18	8	.	.	.	.	.	38	.	13	82	4	15	21	.	.	.	.	12	.	.	.	.	.	.	.	.	70	26	.	20	.	.
Gentiana verna	.	.	.	.	.	.	11	.	6	.	.	.	.	10	.	.	6	.	5	.	.	.	4	.	.	.	.	.	.	29	.	.	.	.	.	.	11	.	30	63	.	20	.	.
Agrostis alpina	.	33	.	.	.	29	5	.	6	.	.	9	.	10	.	.	.	.	10	5	.	.	.	8	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthyllis vulneraria subsp. alpestris	.	22	.	.	.	.	5	.	6	.	57	.	23	.	.	.	.	.	10	.	13	45	8	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla crantzii	.	.	.	.	.	.	.	61	6	62	.	18	.	.	.	.	6	.	.	.	.	.	.	.	28	.	86	.	.	.	.	.	.	.	.	82	.	.	50	.	.	60	.	.
Acinos alpinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	8	.	.	.	.	.	.	4	.	.	.	.	5	33	14	.	26	.	20	.	.
Minuartia verna (incl. subsp. attica)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	.	.	.	.	.	.	.	.	.	.	29	.	4	.	.	.	.	.	.	36	11	.	90	37	50	.	18	.
Biscutella laevigata	.	33	.	.	.	.	.	.	6	.	71	.	.	.	.	.	.	.	.	.	.	73	.	.	17	31	.	.	.	.	.	.	.	.	.	5	.	.	10	.	.	.	.	.
Myosotis alpestris	.	11	20	.	.	.	.	.	.	8	.	9	8	.	13	.	6	.	.	.	.	.	.	.	.	.	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhinanthus glacialis	.	.	.	.	20	50	.	.	18	.	.	9	.	.	.	.	18	8	5	.	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex atrata	.	.	20	17	10	.	.	.	.	.	.	9	.	.	.	.	6	17	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Traunsteinera globosa	.	.	.	.	10	.	.	.	18	.	.	.	.	.	.	.	18	8	.	.	.	36	4	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Antennaria carpatica	.	11	.	.	20	7	.	6	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4. cont.

NMDS Group		A										B										C						D					E							F				
Column numbers.	**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**
Number of relevés for each column	**6**	**9**	**5**	**6**	**10**	**14**	**19**	**18**	**14**	**13**	**7**	**11**	**7**	**10**	**8**	**12**	**17**	**12**	**21**	**20**	**16**	**11**	**25**	**13**	**29**	**16**	**7**	**19**	**24**	**17**	**24**	**20**	**16**	**15**	**8**	**22**	**9**	**7**	**10**	**19**	**6**	**5**	**11**	**11**
Aster bellidiastrum	.	.	.	.	.	.	.	.	.	.	.	9	46	.	.	.	6	.	14	.	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.
Lotus alpinus	.	.	.	83	.	.	.	.	.	.	.	9	.	.	.	8	.	.	.	.	75	.	.	.	69	.	.	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aster alpinus	.	.	40	.	.	.	5	.	12	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Erigeron uniflorus	.	.	60	.	.	.	.	.	6	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stachys alopecurus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	55	.	8	.	.	.	.	.	.	.	.	.	40	.	.	.	.	30	.	.	.	.	.
Alchemilla conjuncta (incl. A. plicatula)	.	.	.	.	.	.	.	.	.	.	.	9	8	.	.	.	.	.	.	.	19	.	64	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arabis ciliata	.	.	.	.	.	.	.	.	.	8	.	.	8	.	.	.	12	.	.	.	.	.	.	.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Armeria majellensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	55	.	.	44	.	70	.	.	20	.	.
Carex ferruginea	.	.	.	.	.	.	.	.	.	.	.	18	.	.	.	.	.	8	19	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex kitaibeliana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	63	33	.	27	.
Hieracium bifidum	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.	5	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.	.
Leucanthemum adustum	.	.	.	.	.	.	.	.	.	.	.	45	.	.	.	.	.	.	.	.	31	.	40	.	.	.	.	.	.	.	.	.	.	.	25	.	.	.	.	.	.	.	.	.
Leucanthemum heterophyllum	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	5	.	.	10	.	.	.	.	.
Pedicularis elongata	.	.	.	.	.	36	5	.	.	.	.	.	.	20	.	.	18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sesleria caerulea	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.	5	.	13	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene acaulis	.	11	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scheuchzerio-Caricetea nigrae																																												
Selaginella selaginoides	.	78	40	33	10	14	.	22	18	.	43	36	92	60	.	.	18	42	43	.	50	.	24	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Bartsia alpina	83	89	.	.	.	.	.	6	29	8	.	27	62	.	13	8	12	8	5	.	25	.	4	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parnassia palustris	17	44	.	17	.	.	.	6	6	.	.	.	.	10	.	.	18	.	19	.	.	.	.	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Carex nigra	.	.	.	17	.	.	.	22	.	.	.	.	.	.	.	8	6	.	38	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex capillaris	.	.	.	.	.	.	.	11	6	.	.	.	.	10	.	.	.	8	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tofieldia calyculata	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.	6	.	14	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Willemetia stipitata	.	.	.	.	.	.	.	.	.	.	.	9	.	.	.	.	.	25	43	.	56	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Koelerio-Corynehoretea																																												
Thymus preacox subsp. polytrichus	.	.	60	17	20	21	37	33	29	62	57	18	.	50	63	8	59	25	14	70	38	55	.	62	41	56	43	13	54	41	4	.	.	.	.	.	.	.	.	.	.	.	72	.
Rumex acetosella	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	8	.	.	.	.	.	.	.	.	14	.	.	.	.	24	.	60	63	93	50	73	11	.	.	32	.	.	.	18
Cerastium arvense subsp. strictum	.	.	40	.	.	.	.	22	53	69	.	.	23	.	.	.	.	.	24	.	.	91	.	15	.	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene rupestris	.	.	60	.	.	7	16	83	.	77	43	.	.	.	.	.	18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago maritima subsp. serpentina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	7	25	12	.	.	.	.	.	.	.	.	.	.	100	.	.	.
Sempervivum montanum	.	.	40	.	.	.	16	50	.	46	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mulgedio-Aconitetea																																												
Veratrum album subsp. lobelianum	17	22	.	.	.	7	.	.	6	.	.	27	.	20	.	.	12	42	43	.	63	55	40	.	34	31	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium spinosissimum	.	56	.	50	.	7	11	11	6	15	.	9	.	.	.	8	12	8	.	5	.	.	.	15	.	.	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gnaphalium norvegicum	.	.	60	.	60	21	.	.	.	.	.	.	.	30	38	.	6	33	.	.	.	.	.	.	34	.	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex alpestris	.	11	.	.	.	.	.	.	.	8	.	.	15	10	.	8	29	8	19	.	.	.	.	62	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viola biflora	.	.	.	17	.	.	.	33	.	8	.	55	.	.	.	.	24	.	14	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula luzuloides (incl. subsp. rubella)	.	.	.	.	.	7	42	.	12	.	.	.	.	10	.	.	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27
Alnus viridis	.	.	.	17	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	5	6	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex alpinus	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	.	12	.	.	.	25	.	.	15	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salicetea herbaceae																																												
Gnaphalium supinum	.	.	.	.	10	.	.	11	.	.	.	18	.	10	.	.	.	.	.	.	6	.	.	.	.	.	.	7	.	.	12	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula alpinopilosa	.	22	.	.	.	14	.	.	.	.	.	9	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	7	.	.	46	.	.	.	.	.	.	.	.	.	.	.	.	.
Sagina saginoides	.	.	.	.	.	.	.	17	.	.	.	.	31	.	.	.	12	.	5	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salix retusa	.	67	20	.	.	.	.	.	6	.	.	.	77	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sibbaldia procumbens	.	11	.	.	.	.	.	17	.	23	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sedum alpestre	.	11	.	.	.	.	.	28	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.
Soldanella pusilla	.	33	.	33	.	.	.	.	.	.	.	.	.	20	.	.	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica alpina	.	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	6	.	10	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinio-Piceetea																																												
Vaccinium myrtillus	67	11	.	67	80	93	42	78	29	85	43	64	38	80	50	50	41	83	52	70	69	91	60	77	.	56	14	87	75	41	33	.	.	.	.	.	.	.	40	.	.	.	.	36
Homogyne alpina	33	100	.	83	80	86	5	78	29	54	.	91	92	90	38	58	29	67	62	2	25	.	44	15	24	.	29	13	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium vitis-idaea	.	.	.	33	50	29	42	22	.	38	71	72	31	40	25	33	35	25	24	45	13	36	.	38	.	.	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
Luzula sieberi	.	.	.	.	10	7	.	.	6	.	.	82	.	20	25	8	24	42	.	5	69	82	12	77	.	.	.	7	25	.	.	.	.	.	13	.	11	.	.	.	.	.	.	.
Rhododendron ferrugineum	17	.	.	17	.	71	53	50	29	23	.	.	8	40	13	17	6	.	.	5	.	.	.	23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Picea abies	.	.	.	33	.	.	11	.	.	.	.	.	.	.	.	.	.	.	5	30	13	.	.	69	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Larix decidua	17	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	54	.	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Huperzia selago	33	.	.	.	.	7	.	6	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Loiseleurio-Vaccinietea																																												
Vaccinium gaultherioides	17	22	.	50	80	64	32	78	12	31	29	27	.	30	13	33	18	8	10	15	.	.	4	.	17	13	29	40	17	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.
Juniperus communis subsp. alpina	.	.	.	33	.	.	74	8	53	23	.	.	.	.	.	.	.	.	5	.	.	36	.	23	.	.	14	7	25	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypericum richeri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	20	71	41	21	.	13	20	.	.	.	.	.	11	.	.	.	.
Diphasiastrum alpinum	17	.	.	.	20	.	.	11	.	.	.	.	.	.	13	.	.	17	.	.	.	.	24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Loiseleuria procumbens	.	22	.	.	.	.	5	6	.	8	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4. cont.

NMDS Group		A										B										C						D					E						F					
Column numbers.	**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**
Number of relevés for each column	**6**	**9**	**5**	**6**	**10**	**14**	**19**	**18**	**14**	**13**	**7**	**11**	**7**	**10**	**8**	**12**	**17**	**12**	**21**	**20**	**16**	**11**	**25**	**13**	**29**	**16**	**7**	**19**	**24**	**17**	**24**	**20**	**16**	**15**	**8**	**22**	**9**	**7**	**10**	**19**	**6**	**5**	**11**	**11**
Other companions																																												
Anhoxanthum odoratum (incl. nipponicum)	100	100	80	100	100	100	89	89	76	92	100	91	100	100	50	83	76	75	100	90	69	100	80	77	69	88	71	33	79	53	12	.	100	93	50	45	33	43	90	58	83	20	45	82
Festuca rubra subsp. commutata (incl. F. microphylla)	.	56	100	83	70	86	95	94	71	100	86	100	100	90	100	100	94	58	48	90	81	91	100	100	59	81	100	93	96	82	79	100	81	100	100	100	56	86	100	58	100	100	82	45
Campanula scheuchzeri	67	100	80	100	80	64	89	89	53	92	86	91	100	70	50	58	59	58	76	55	75	91	92	92	21	56	57	.	33	24	8	.	.	.	.	.	.	29	80	26	17	60	27	.
Deschampsia flexuosa	.	44	.	17	90	86	89	6	65	8	14	100	23	100	25	.	41	50	10	5	6	18	.	.	.	31	14	7	62	29	4	95	6	67	50	.	.	.	.	.	.	.	.	36
Carex sempervirens	100	89	100	100	40	64	74	94	88	92	71	45	77	80	13	67	35	.	29	10	25	.	12	.	76	75	71	47	21	.	46	.	.	.	.	.	.	.	.	.	.	.	.	9
Ranunculus gr. montanus	.	22	60	33	.	14	32	50	59	77	57	.	100	10	88	67	12	8	48	30	6	45	.	62	48	19	71	.	.	.	.	.	75	60	.	.	.	57	.	.	.	.	.	.
Calluna vulgaris	33	11	.	33	40	43	74	61	35	46	86	.	38	90	50	58	59	82	.	60	13	9	4	46	.	.	.	.	.	.	.	40	.	.	.	.	.	.	.	.	.	.	.	.
Soldanella alpina	.	33	20	.	.	7	11	61	59	46	57	36	100	20	.	8	18	8	57	5	25	73	.	15	.	63	.	.	.	6	4	.	.	.	.	.	.	.	.	.	.	.	.	.
Bistorta vivipara	.	89	80	50	50	.	.	.	47	.	43	45	85	10	13	.	6	25	33	.	44	73	20	38	24	56	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica chamaedrys	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	12	17	10	.	19	91	.	62	.	6	.	.	.	.	.	.	.	.	25	5	.	14	.	.	.	.	.	55
Brachypodium genuense	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	67	6	12	.	.	.	88	82	11	71	20	16	67	.	.	.
Silene nutans	17	.	.	.	.	.	5	17	.	38	.	.	.	.	.	.	29	8	.	.	.	9	8	23	.	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Daphne striata	33	.	20	.	.	.	84	22	29	38	71	.	.	.	.	8	.	.	.	.	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Majanthemum bifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	10	13	.	6	.	.	20	6	45	.	.	13	13	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex ornithopoda	.	.	.	.	.	.	.	6	18	.	.	.	62	.	.	.	.	8	14	.	25	36	.	.	.	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciata glabra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	.	54	.	.	.	.	12	.	.	95	.	7	25	23	.	.	.	.	.	.	.	64
Chaerophyllum hirsutum	.	.	.	.	.	29	.	6	6	.	.	.	.	50	.	.	6	.	.	5	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dactylorhiza fuchsii	.	.	.	.	.	.	.	.	6	.	.	.	.	.	25	.	12	17	14	.	.	27	.	.	.	.	.	.	.	.	.	30	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium murorum	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	17	6	.	.	.	50	.	28	31	.	.	.	.	.	.	.	35	.	.	.	.	.	.	.	.	.	.	.	.
Geranium sylvaticum	.	.	.	.	20	.	.	.	.	.	.	9	.	10	.	.	47	8	.	.	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardamine resedifolia	.	.	20	.	.	.	.	17	.	23	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.	.	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciata laevipes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27	.	.	.	.	.	.	.	.	.	5	.	.	25	.	.	43	.	11	.	.	.	.
Hieracium lachenalii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38	.	.	.	.	.	13	.	.	.	13	13	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Rare species. Nardion strictae: Alopecurus gerardi (25, 27, 43); Gentiana pannonica (17, 19); Ranunculus kuepferi (25, 27).Caricetalia and Cariceta curvulae: Alchemilla flabellata (2, 9, 25); Alchemilla hybrida (5, 18, 26); Carex curvula (2, 3, 8); Centaurea uniflora (25, 26, 27); Dianthus pavonius (25, 26, 27); Euphrasia hirtella (8, 10, 26); Laserpitium halleri (1, 7, 11); Minuartia recurva (3, 7, 27); Phyteuma michelii (25, 26, 27); Silene exscapa (3, 8, 10); Veronica allionii (25, 26, 27); Gentiana purpurea (13, 15); Juncus jacquinii (2, 5); Ligusticum mutellinoides (2, 10); Primula daonensis (3, 11); Primula minima (2, 6); Senecio incanus subsp. Carniolicus (2, 6); Androsace adfinis (25); Armeria marginata (30); Festuca riccerii (29); Gentiana ramosa (3); Hieracium fuscum (5); Paradisea liliastrum (22); Phyteuma pedemontanum (25); Primula integrifolia (8); Sempervivum wulfenii (7). Nardetea strcitae: Genista sagittalis (15, 33, 34); Hypericum maculatum subsp. obtusiusculum (12, 19, 21); Bellis pusilla (41, 43); Hieracium aurantiacum (5, 1); Hieracium gothicum (5, 18); Thesium pyrenaicum (21,23); Viola aethnensis subsp. splendida (41, 43); Achillea tenorii (35); Campanula serrata (44); Festuca violacea subsp. italica (40); Luzula pindica (43); Viola lutea subsp. sudetica (44). Molinio-Arrhenathereta: Centaurea pseudophrygia (9, 18, 21); Chaerophyllum villarsii (4, 16, 22); Pimpinella major (15, 17, 21); Rhinanthus angustifolius (29, 33, 34); Trisetum flavescens (22, 26, 34); Achillea roseoalba (17, 22); Crepis mollis (21, 23); Equisetum palustre (4, 33); Festuca arundinacea (21, 24); Festuca pratensis (21, 44); Galium album (24, 32); Hypochaeris radicata (21, 44); Juncus conglomeratus (20, 33); Phleum pratense (21, 24); Poa pratensis (22, 35); Ranunculus polianthemoides (33, 34); Rhinanthus minor (22, 23); Carex hirta (33); Centaurea nigrescens (22); Cirsium palustre (21); Euphorbia gasparrinii subsp. samnitica (35); Heracleum sphondylium (21); Juncus effuses (21); Phleum bertolonii (33); Tephroseris helenitis (22); Tragopogon pratensis (34); Trifolium hybridum (32). Festuco-Brometea: Bromus erectus (22, 35, 40); Carex macrolepis (35, 36, 39); Festuca circummediterranea (37, 38); Filipendula ulmaria (33, 34, 35); Galium lucidum (29, 37, 40); Helianthemum nummularium (7, 20, 26); Helictotrichon pratense (6, 17, 34); Hieracium cymosum (22, 26, 35); Koeleria macrantha (33, 34, 37); Primula veris (incl. subsp. columnae) (25, 26, 35); Prunella grandiflora (9, 17, 26); Veronica orsiniana (34, 36, 42); Achillea collina (37, 38); Achillea setacea (38, 40); Campanula glomerata (34, 35); Cerastium tomentosum (41, 43); Knautia purpurea (35, 40); Ornithogalum gussonei (33, 34); Plantago atrata subsp. fuscescens (25, 29); Polygala amarella (21, 40); Saxifraga granulata (33, 34); Scabiosa columbaria (4, 15); Thesium linophyllon (41, 43); Thlaspi praecox (42, 17); Asperula aristata subsp. scabra (41); Astragalus danicus (26); Astragalus hypoglottis subsp. gremlii (34); Centaurea jacea subsp. gaudinii (35); Cynoglossum magellense (40); Erodium alpinum (38); Festuca bosniaca (43); Helianthemum canum (20); Leontodon tuberosus (36), Potentilla neumanniana (26), Veronica austriaca (43). Elyno-Seslieietea: Euphrasia salisburgensis (21, 24, 42); Festuca laevigata (26, 35, 40); Festuca violacea subsp. violacea (25, 26, 27); Gentiana anisodonta (2, 6, 17); Helianthemum nummularium subsp. grandiflorum (21, 22, 24); Horminum pyrenaicum (9, 17, 20); Koeleria eriostachya (9, 17, 24); Linum alpinum (26, 35, 39); Pedicularis rostrato-spicata subsp. helvetica (2, 25, 26); Pedicularis verticillata (2, 9, 16); Senecio abrotanifolius (7, 9, 24); Senecio doronicum (incl. subsp. gerardi) (34, 35, 36); Alchemilla colorata (35, 40); Elyna myosuroides (2, 3); Gymnadenia odoratissima (17, 21); Knautia longifolia (17, 22); Pedicularis rostratocapitata (8, 10); Scabiosa lucida (23, 44); Tephroseris capitata (25, 26); Anemone narcissiflora (9); Anthyllis vulneraria subsp. pulchella (40); Bupleurum ranunculoides (26); Dianthus alpinus (19); Erigeron epiroticus (40); Festuca melanopsis (2); Festuca norica (9); Galium baldense (22); Gentiana engadinensis (3); Helianthemum nummularium subsp. glabrum (19); Hieracium villosum (7); Homogyne discolor (19); Leucanthemum atratum (19); Nigritella corneliana (25); Nigritella rubra (22); Pedicularis gyroflexa (25); Pulsatilla alpina subsp. millefoliata (39); Rhinanthus wettsteinii (40); Salix serpyllifolia (12); Scorzonera rosea (17); Taraxacum emilianum (30). Scheuchzero-Caricetea nigrae: Carex gr. flava (19, 20, 21); Agrostis canina (33, 34); Carex panicea (19, 21); Carex stellulata (4, 21); Eriophorum angustifolium (2, 4); Juncus articulates (17, 21); Trichophorum caespitosum (4, 20); Carex limosa (20); Dactylorhiza majalis (21). Koelerio-Corynephoretea: Cerastium semidecandrum (32); Petrorhagia saxifraga (41); Scleranthus perennis (43); Sedum annuum (17). Mulgedio-Aconitetea: Knautia dipsacifolia (12, 15, 23); Poa chaixii (7, 23, 44); Athyrium distentifolium (20, 21); Phyteuma ovatum (7, 20); Aconitum gr. napellus (7); Calamagrostis villosa (1); Senecio subalpinus (19). Salicetea herbaceae: Alchemilla fissa (6, 14, 18); Taraxacum alpinum (10, 17, 27); Arenaria biflora (8, 24); Carex foetida (27, 31); Salix herbacea (2, 4); Galium noricum (19); Soldanella austriaca (19). Vaccinio-Piceetea: Luzula luzulina (15, 19, 23). Loiseulerio-Vaccinietea: Astrantia minor (4, 10, 16); Arctostaphylos uva-ursi (7). Other classes and Companions: Achillea moschata (7, 8, 10); Arabis collina (36, 39, 40); Campanula apennina (35, 36, 39); Centaurea montana (21, 26, 34); Centaurea triumfetti (22, 30, 35); Dryopteris filix-mas (10, 20, 21); Fragaria vesca (20, 21, 24); Genista germanica (17, 20, 22); Hypericum perforatum (20, 34, 35); Juniperus communis (16, 20, 32); Lilium martagon (21, 26, 32); Luzula nivea (6, 22, 32); Phyteuma spicatum (12, 21, 24); Platanthera clorantha (21, 22, 32); Rubus idaeus (1, 24, 32); Silene multicaulis (36, 41, 42); Trifolium alpestre (27, 35, 36); Trifolium ochroleucon (25, 33, 41); Trifolium pallescens (4, 9, 27); Athamanta cretensis (10, 12); Bunium bulbocastanum (38, 40); Chamaecytisus hirsutus (17, 22); Cirsium tenoreanum (38, 41); Clinopodium vulgare (36, 38); Daphne mezereum (7, 32); Digitalis ferruginea (37, 38); Erica carnea (16, 20); Galeopsis tetrahit (20, 24); Gentiana utriculosa (24, 34); Hypericum humifusum (20, 32); Listera ovata (6, 21); Lysimachia nemorum (19, 21); Myosotis sylvatica (10, 17); Oreopteris limbosperma (19, 21); Phyteuma scheuchzeri (20, 22); Plantago major (10, 21); Polygala chamaebuxus (9, 16); Ranunculus aconitifolius (12, 21); Ranunculus breyinus (13, 26); Ranunculus lanuginosus (18, 32); Silene quadrifida (19, 24); Thlaspi alpestre (19, 26); Viola reichenbachiana (22, 30); Acer pseudoplatanus (21); Alchemilla anisiaca (19); Alchemilla coriacea (27); Alchemilla decumbens (12); Betula pendula (1); Campanula kladniana (44); Carex sylvatica (21); Cirsium lobelii (37); Crepis leontodontoides (32); Cytisus scoparius (32); Festuca stenantha (9); Galium carmineum (22); Hieracium piloselloides (32); Hypericum montanum (22); Jasione orbiculata (41); Malaxis monophyllos (21); Melampyrum pratense (24); Phyteuma scorzonerifolium (30); Picris hieracioides (32); Pimpinella lithophila (41); Primula hirsute (10); Pteridium aquilinum (20); Rhinanthus freyinii (17); Rumex thyrsiflorus (27); Sedum atratum (10); Soldanella hungarica subsp. major (44); Stachys heraclea (38); Stellaria media (20); Thalictrum flavum (34); Valeriana wallrothii (22); Viola rupestris (26).

Table 5. Average frequencies of diagnostic species of the phytosociological classes and the chorotypes within the different groups of synoptic tables. *P*-values refer to Kruskal-Wallis test ($P < 0.001$ in bold types). Different letters indicate cross significant differences (Wilcoxon test, $P < 0.05$) between phytosociological class and chorotype pairs.

	Group A	Group B	Group C	Group D	Group E	Group F	*P*-value
Phytosociological classes							
Caricetea curvulae	51.3 ± 4.2 c	31.9 ± 8.0 d	9.4 ± 1.7 b	33.6 ± 8.7 d	5.3 ± 1.1 a	9.6 ± 1.8 b	< 0.001
Nardetea strictae	10.0 ± 4.3 a	16.7 ± 3.6 b	18.7 ± 5.7 abd	16.3 ± 4.9 ab	24.7 ± 4.6 dc	28.2 ± 7.0 c	< 0.001
Molinio-Arrhenatheretea	7.4 ± 3.8 a	15.7 ± 5.2 b	31.3 ± 1.9 c	20.1 ± 5.3 bd	36.9 ± 15.9 dc	17.0 ± 4.6 b	< 0.001
Festuco-Brometea	1.3 ± 1.2 a	2.3 ± 1.7 a	5.7 ± 1.7 b	5.1 ± 5.4 abd	14.0 ± 3.6 dc	21.5 ± 7.1 c	< 0.001
Elyno-Seslerietea	6.6 ± 5.2	5.7 ± 2.9	7.9 ± 3.8	6.9 ± 5.1	1.3 ± 2.2	12.7 ± 9.2	0.064
Loiseleurio-Vaccinietea	1.0 ± 0.9 bc	1.8 ± 1.4 dc	0.6 ± 0.4 bd	3.1 ± 2.1 c	0.3 ± 0.3 ab	0.1 ± 0.2 a	< 0.001
Koelerio-Corynephoretea	1.8 ± 3.1	1.9 ± 1.6	1.7 ± 1.2	2.4 ± 1.6	3.0 ± 1.2	2.3 ± 2.7	0.696
Scheuchzerio-Caricetea nigrae	4.0 ± 2.6 b	2.2 ± 2.3 b	1.7 ± 2.2 b	0.0 ± 0.1 a	1.7 ± 1.8 ab	–	0.007
Vaccinio-Piceetea	3.8 ± 4.3 abc	6.1 ± 2.1 c	5.8 ± 2.0 dc	3.2 ± 2.2 bd	–	0.3 ± 0.6 a	< 0.001
Salicetea herbaceae	1.6 ± 2.3	1.1 ± 1.2	0.2 ± 0.3	1.5 ± 2.6	–	–	0.217
Mulgedio-Aconitetea	2.2 ± 0.5 bd	1.9 ± 1.2 d	2.0 ± 0.8 bd	0.8 ± 1.2 ab	0.2 ± 0.3 a	–	0.032
Others	9.2 ± 2.3 ad	12.7 ± 2.3 c	15.0 ± 5.0 dc	7.1 ± 4.1 ab	12.7 ± 12.2 bdc	8.2 ± 5.6 ad	0.016
Chorotypes							
Cosmopolitan	2.5 ± 0.1 b	3.0 ± 1.7 bd	3.2 ± 1.2 bd	2.7 ± 1.2 bd	5.1 ± 1.1 d	0.8 ± 0.7 a	0.003
Circumboreal	8.1 ± 1.2 b	13.4 ± 2.4 c	14.2 ± 3.2 dc	11.6 ± 3.9 bc	8.8 ± 2.3 bd	5.8 ± 1.6 a	< 0.001
Arctic-Alpine	8.7 ± 2.3 d	4.7 ± 2.3 b	1.5 ± 0.7 a	5.3 ± 2.8 bd	–	1.2 ± 1.8 a	< 0.001
Eurosiberian	8.1 ± 4.9 dc	10.8 ± 3.2 c	18.6 ± 2.6 a	13.1 ± 3.3 bdc	27.3 ± 10.3 ab	16.3 ± 5.1 ad	< 0.001
Eurasian (incl. European)	8.0 ± 0.8 a	19.2 ± 5.5 d	31.9 ± 3.7 c	14.0 ± 7.5 ab	41.6 ± 6.9 c	18.8 ± 6.8 bd	< 0.001
CS European Orophytes	55.4 ± 1.7 e	44.8 ± 6.4 c	26.9 ± 3.0 d	40.6 ± 5.9 c	7.6 ± 2.9 a	18.3 ± 7.8 b	< 0.001
Mediterranean	–	0.1 ± 0.3 a	0.7 ± 0.7 b	0.1 ± 0.3 ab	5.1 ± 0.6 d	6.2 ± 3.8 d	0.002
Mediterranean Orophytes	–	–	–	2.2 ± 2.9 a	1.0 ± 0.5 a	10.8 ± 6.1 b	< 0.001
Endemic	9.3 ± 0.7 b	4.2 ± 2.7 a	2.9 ± 1.9 a	10.3 ± 3.6 b	3.4 ± 2.8 a	22.0 ± 4.3 d	0.966

sociological classes the species of Caricetea curvulae, and those of Vaccinio-Piceetea and Loiseleurio-Vaccinetea have their occurrence peak within the *Nardus* communities from the Alps, respectively within group A, group B and group D; whereas the species of Nardetea strictae and Festuco-Brometea mainly occur in the central and southern Apennines.

Discussion

A sound and consistent classification of vegetation on a territorial basis is generally regarded as an important tool for vegetation monitoring and developing conservation strategies. In the last decades, with the accumulation of phytosociological data at regional scale, the need for overall frameworks of classification of the plant communities at larger territorial levels became ever more pressing. Several comprehensive national vegetation overviews based on vegetation databases were produced during this period (e.g. Rodwell 1991–1995, Schaminée et al. 1995–1999, Valachovič 1995–2001, Chytrý 2007–2011), in parallel to the first supranational classifications dealing with entire vegetation classes or high syntaxa (e.g. Zechmeister & Mucina 1994, Dengler et al. 2006b, Michl et al. 2010, Blasi et al. 2012b).

Also in Italy, a national vegetation database (VegItaly) was recently planned and developed with the aim of accomplishing a national and systematic treatment of vegetation (Landucci et al. 2012), just as the number of phytosociological studies at regional or supraregional scale increased considerably (see Blasi et al. 2004, Biondi et al. 2005, Sburlino et al. 2008, Blasi et al. 2012a and others).

In line with this trend, we performed this regional phytosociological survey focused on the northern Apennine *Nardus*-rich grasslands aiming at filling a gap in the knowledge on the above tree-line vegetation of this phytogeographically border-line mountain system. The pa-

Table 6. Type relevés of the three new subassociations: VF-NA cg = Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis; VF-NA lm = Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae; VF-NA pr = Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; TC: territorial characteristic species.

Vegetation type	VF-NA cg	VF-NA lm	VF-NA pr
Relevé n.	32	64	105
Site	PR	VE	TA
Elevation (m a.s.l.)	1840	1620	1630
Aspect (°)	NE	WNW	WNW
Slope angle (°)	15	10	15
Relevé area (mq)	10	80	8
Vegetation cover (%)	100	60	80
Violo ferrarinii-Nardetum strictae			
Nardion strictae			
Nardus stricta (ALD)	4	5	4
Festuca rubra subsp. commutata(ALD)	1	1	1
Geum montanum	+	1	.
Pedicularis tuberosa	.	+	.
Potentilla aurea	+	.	.
Viola ferrarinii	.	+	.
subass. crepidetosum glabrescentis			
Poa alpina	1	1	+
Crepis aurea subsp. glabrescens	1	.	1
Plantago alpina	1	.	.
Luzula alpinopilosa	+	.	.
subass. luzuletosum multiflorae			
Deschampsia flexuosa	.	1	.
Genista tinctoria	.	1	.
Brachypodium genuense	.	+	.
Luzula multiflora	.	+	.
Polygala alpestris	.	+	.
subass. phleetosum rhaetici			
Alchemilla gr. vulgaris	.	.	1
Trifolium pratense	.	.	1
Gentiana verna	.	.	+
Lotus corniculatus	.	.	+
Phleum rhaeticum	.	.	+
Ranunculus pollinensis	.	.	+
Caricetalia and Caricetea curvulae			
Alchemilla gr. alpina	+	1	+
Agrostis rupestris	+	.	+
Anthoxanthum odoratum subsp. nipponicum	+	r	.
Carex sempervirens (TC)	+	.	.
Euphrasia minima	.	.	+
Companions			
Nardetea strictae	.	.	.
Dianthus deltoides	.	+	.
Veronica officinalis	.	r	.
Molinio-Arrhenatheretea			
Bistorta officinalis	.	+	.
Crocus vernuus	.	+	.
Sagina glabra	.	.	+
Other companions			
Hypericum richeri	+	+	+
Vaccinium myrtillus	+	+	.
Pimpinella saxifraga	.	1	.
Brachypodium genuense	+	.	.
Campanula scheuchzeri	.	+	.
Cruciata glabra	.	+	.
Galium anisophyllon	.	+	.
Thymus praecox subsp. polytrichus	.	+	.
Vaccinium gaultherioides	+	.	.

per comes after other monographic studies on the summit vegetation of this area (Gerdol & Tomaselli 1987, 1993, Ferrari & Piccoli 1997, Tomaselli et al. 2000, Petraglia & Tomaselli 2007) and it is based on a data set considerably larger than those used by all the authors that previously investigated these communities in the territory. The wider perspective so available enabled us to clarify some still unresolved syntaxonomic problems and to explore more deeply the compositional variability of these communities, related to habitat factors.

Our results confirmed the occurrence in the northern Apennines of two main different phytosociological types of *Nardus stricta*-grasslands, that are worthy of separation because of their marked floristic distinction (Carlino caulescentis-Nardetum strictae and Violo ferrarinii-Nardetum strictae). Both vegetation types were already classified as independent associations, by Viciani & Gabellini (2000) and Credaro & Pirola (1975), respectively. The overall floristic characters between the associations presented so much a contrast that justified their disjunction into two different classes (Nardetea strictae and Caricetea curvulae). The separation of *Nardus* communities into these two classes is in line with the syntaxonomical proposal of Theurillat et al. (1995) for the Alps. The still open question of the affiliation of the Carlino caulescentis-Nardetum strictae at the alliance level was solved placing it in the Nardo-Agrostion tenuis, extending the distribution range of this alliance from the south-eastern Alps to the northern Apennines. Nardo-Agrostion has, however, received only incidental mention in previous studies on the Italian mountains and further sampling is required to provide a comprehensive account of this kind of vegetation and to define its boundaries towards the parallel alliance Violion caninae.

The enlarged data set provided also the basis for a more precise and comprehensive definition of the Violo ferrarinii-Nardetum strictae, whose original diagnosis was established on only six phytosociological relevés. The more documented and detailed analysis revealed that the association brings together a variety of floristically heterogeneous situations here erected as different subassociations within a single distinct compendious association. A similar wide range of floristic variation was documented also for the Sieversio montanae-Nardetum strictae Lüdi 1948 from the Alps, (see Appendix 1 for details on the nomenclatural aspect). This association, which is the floristically nearest equivalent to the Violo ferrarinii-Nardetum strictae of the northern Apennines, was recently classified into four distinct subassociations by Lüth et al. (2011) in a cross-section study along the eastern Alps. Among them, the subassociation trifolietosum pratensis showed a strict floristic resemblance with the subassociation phleetosum rhaetici of the Violo ferrarinii-Nardetum strictae.

Elevation proved to be the environmental variable explaining most of the floristic variation within the *Nardus*-rich communities in the northern Apennines, in spite of the potential overestimation of the importance of the ecological indicators derived by plant abundances data. The species belonging to the Caricetea curvulae gradually decrease at lower altitudes, whereas those of Nardetea strictae show an opposite distribution pattern along the altitudinal gradient. The two components are practically balanced at the level of the Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae, whose stands are mostly distributed from 1600 and 1700 m corresponding to the high-montane vegetation belt.

The leading role plaid by the altitudinal gradient in determining floristic variation in the *Nardus* grasslands has been recognized since quite a while. Several authors have, in fact, observed similar patterns in the Alps (Oberdorfer 1978, Herter 1990, Poldini & Oriolo 1997) and in the central Apennines (Gigli et al. 1991, Biondi et al. 1999). On the other hand, *Nardus*-rich grasslands, being secondary plant communities, are necessarily conditioned in their floristics by the surrounding vegetation.

Not all Ellenberg's indicator values used in the RDA ordination proved to be equally suitable as explanatory variables of habitat features. Such variables as light intensity and continentality cannot be ecologically predictive within our narrow habitat gradients. The light intensity values in our stands are, in fact, mostly conditioned by the occurrence of ericaceous sub-shrubs, whose indicator values reported by literature are based on the assumption that they occur optimally as shaded under a forest canopy. Nevertheless, in the *Nardus*-grasslands these sub-shrubs don't grow in shaded conditions at all. The values of continentality are increased by the occurrence of the Central-Southern European-orophytes belonging to the class Caricetea curvulae. It is, however, scarcely plausible that the predominance of these species can really reflect a continentality gradient at a so fine territorial scale. From these examples it comes clearly to light that the indicator values can have an objective ecological meaning only when species response don't shift along a coenological gradient, differing between different vegetation types, as already suggested by Diekmann (2003).

The comparison of synoptic tables of *Nardus* communities from the Alps and the Apennines showed that the most relevant compositional changes, corresponding to possible biogeographical and ecological thresholds, occur at the level of the south-western Alps and the northern Apennines. The first dividing line is in the south-western Alps, whose *Nardus* communities resulted floristically closer to the Violo ferrarinii-Nardetum strictae than to the Sieversio montanae-Nardetum strictae of the Alps. Biogeography provides a first possible explanation of this pattern, for the higher occurrence of endemic species (mostly SW Alpic and Apennine) and Mediterranean orophytes in the group including the stands from the south-western Alps and the northern Apennines. Another plausible explanation can be found in the climatic differences determined by the latitudinal thermal gradient, to which is associated a reduced amount of summer precipitation (Richard 1985).

A second sharper dividing line is between the northern and the central Apennines. Also here biogeography provides a convincing explanation of the floristic patterns, because the boreal species and, especially, the central-southern European orophytes dramatically decrease south of the northern Apennines, where they survive only in refugial habitats, while endemic species and Mediterranean orophytes substantially increase in the central and southern Apennines. At the level of the northern Apennines there is also the southernmost Italian outpost of the alliance Nardion strictae and, more in general, of all the Caricetea curvulae communities, whose floristic bulk is precisely given by the central-southern European orophytes. A key role in determining these compositional differences is also played by the latitudinal thermal gradient occurring here along the Italian peninsula. It likely explains the increase of termophilous Mediterranean species, of the species of the class Molinio-Arrhenatheretea and of the xerothermophilous species of the class of Festuco-Brometea occurring in the central-southern Apennines.

A further result of the ordination of synoptic tables was the separation between the montane stands of the marginal calcareous massifs of the Alps and the subalpine ones of the internal alpine mountain systems, hitherto all gathered within the compendious association Nardetum strictae. This strengthens the necessity, already hypothesized by Poldini & Oriolo (1997), of a comprehensive revision of this association in order to better define its boundaries towards the communities of the Nardo-Agrostion tenuis and the Violion caninae.

Concluding remarks

The study documented that the habitat of priority interest "Species-rich *Nardus* grasslands" (code 6230) is hitherto of widespread but local occurrence throughout the whole range of the northern Apennines, despite relaxation and abandonment of grazing, a land-use practice that is locally becoming economically unproductive. As a consequence of their abandonment, these semi-natural ecosystems are progressively invaded by clonal ericaceous sub-shrubs and the likely successor to such changes could be a sort of dwarf shrub heath, floristically similar to the Hyperico richeri-Vaccinietum gaultherioidis. The process seems to be more marked in the subalpine areas where the sampled stands of the Violo ferrarinii-Nardetum strictae in its typical variant are a minority with respect to those of the *Carex sempervirens*-variant, where number, frequency and cover of sub-shrub species are considerably higher.

From the syntaxonomic viewpoint, there is still some way to go to establish a consistent classification of the *Nardus*-rich grasslands in the Italian mountains. For this goal, we primarily need to increase the so far scarce data from the south-western Alps for clearly defining the southward border of the Sieversio montanae-Nardetum strictae and provide further reasoning for a possible separation of some additional associations and subassociations within this region as already proposed by Barbero (1970) and Lacoste (1975). Moreover, further sampling efforts are needed in order to extend our knowledge of the montane *Nardus* communities that so far received negligible attention. This is a relevant goal, necessary for coming to a clear and comprehensive classification of these communities also in reason that in the montane vegetation belt there is the floristic-ecologic boundary between the *Nardus* communities occurring at higher altitude (belonging to the Nardion strictae in the Alps and in the northern Apennines and to the Ranunculo pollinensis-Nardion strictae in the central and southern Apennines) and the those of the Nardo-Agrostion tenuis occurring at lower altitudes.

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Appendices

Appendix 1. Nomenclaturally relevant decision, proposals for correction, typification of name and syntaxonomical scheme.

a) Correction of names

The correct name of *Violo bertolonii-Nardetum* Credaro et Pirola 1975 (= *Geo montani-Nardetum* sensu auct. veg. app. non *Sieversii-Nardetum strictae* Lüdi 1948; = *Nardetum subalpinum* var. a *Viola cavillieri* sensu Barbero et Bonin 1980; = *Violo cavillieri-Nardetum* Credaro et Pirola 1975 corr. Tomaselli 1994) is *Violo ferrarinii-Nardetum strictae* Credaro & Pirola 1975 *nom. corr. hoc loco* according to Art. 43 of the ICPN.

The correct name of *Sieversio-Nardetum strictae* Lüdi 1948 is *Nardetum* Rübel 1911 (*Nardetum* Rübel 1911 Bot. Jahrb. Syst. 47: 163 (1911), lectotypus: ril. 5, table: 165, here selected= *Nardetum* Furrer 1914 Nat. Ges. Zürich, 59: 190 (1914) Art. 31 (Weber et al. 2000); = *Nardetum* Lüdi 1921 Beitr. Geobot. Landesaufn. Schweiz, 9: 87 Art. 31 (Weber et al. 2000); = *Sieversio-Nardetum strictae* Lüdi 1948 Veröff. Geobot. Inst. Rübel, 23: 39 (1948) nomen superflum Art. 22, 29, ICPN lectotypus selected by Peppler-Lisbach and Petersen (2001); = *Nardetum subalpinum* Br.-Bl. (1918) Br.-Bl. Schedae 1918 Nr. 28). According to Grabherr 1993: 361 the name "Nardetum" should be rejected (Art. 36 of the ICPN) as "nomen ambiguum" so the next later valid name for this association that is in accordance with the Rules is *Sieversio-Nardetum strictae* Lüdi 1948 (Art. 39 of the ICPN).

b) Syntaxonomical scheme

Caricetea curvulae Br.-Bl. 1948
- *Caricetalia curvulae* Br.-Bl. in Br.-Bl. et Jenny 1926
  - *Nardion strictae* Br.-Bl. 1926
    - *Violo ferrarinii-Nardetum strictae* Gennai, Foggi, Viciani, Carbognani et Tomaselli
      - subass. *typicum* Gennai, Foggi, Viciani, Carbognani et Tomaselli
      - subass. *crepidetosum glabrescentis* Gennai, Foggi, Viciani, Carbognani et Tomaselli
      - subass. *luzuletosum multiflorae*. Gennai, Foggi, Viciani, Carbognani et Tomaselli
      - subass. *phleetosum rhaetici* Gennai, Foggi, Viciani, Carbognani et Tomaselli

Nardetea strictae Rivas Goday et Borja Carbonell 1961
- *Nardetalia strictae* Oberdorfer 1949 em. Preising 1949
  - *Nardo-Agrostion tenuis* Sillinger 1933
    - *Carlino caulescentis-Nardetum strictae* Viciani et Gabellini 2000 corr. Viciani et Gabellini 2006

Appendix 2. List of relevé sites.

Apuan Alps: (CV) Mt. Cavallo; (FC) Mt. Fiocca; (FG) Foce Giovo; (GA) Mt. Garnerone ridge; (PA) Pania della Croce; (PI) Mt. Pisanino; (PS) Pania Secca; (PU) Mt. Pizzo d'Uccello; (SA) Mt. Sagro; (TA) Mt. Tambura; (UM) Uomo Morto.

Tuscan-Emilian Apennines: (AL) Mt. Albano; (AN) Campi di Annibale; (AQ) Colle Acquamarcia; (BG) Mt. Bragalata; (BO) Mt. Bocco; (BR) Balzo delle Rose; (CA) Calanca Pass; (CE) Mt. Cella; (CF) Pania di Corfino; (CI) Mt. Cimone; (CM) Campaiana saddle; (CP) Campolino; (CS) Corno alle Scale; (CU) Mt. Cusna; (FE) Femminamorta; (FO) Mt. Le Forbici; (GI) Mt. Giovo; (GV) Mt. Giovarello; (LA) Mt. Libro Aperto; (LG) I Lagoni; (MA) Mt. Marmagna; (MT) Mt. Matto; (NS) La Nuda-Scalocchio; (NU) La Nuda modenese; (PC) Pian Cavallaro (Mt. Cimone); (PE) Alpe S. Pellegrino; (PR) Mt. Prado; (RO) Mt. Rondinaio; (SC) Mt. Spicchio; (SI) Mt. Sillara; (SP) Mt. Spigolino; (TO) Mt. Tondo; (TP) Alpe Tre Potenze; (VE) Mt. Ventasso; (VP) Vista del Paradiso.

Appendix 3. Data source of the Table 4.

1. Southern Rhaetian Alps (Adamello-group, Genova valley). *Sieversio-Nardetum strictae*: table 11 (6 relevés) in Zara (2003) unpublished data from a degree thesis at the University of Padua; 2. Dolomites (Marmolada group). *Geo-Nardetum strictae*: table 23 (9 relevés), in Dellavedova (2001), unpublished data from a degree thesis at the University of Pavia; 3. Western Rhaetian Alps (Braulio valley). *Nardetum alpigenum* table 28 (5 relevés) in Giacomini & Pignatti (1955); 4. Southern Rhaetian Alps (Adamello-group, Aviolo valley). *Sieversio-Nardetum strictae*: unnumbered table (6 relevés) in Bertin (2004); 5. North-Eastern Alps (Bavarian Alps). *Aveno-Nardetum*: table 115 col. 1 (10 relevés) in Oberdorfer (1978); 6. Carnic Alps. *Sieverso-Nardetum strictae* typical form: table 4 (rel. 11-24) in Poldini & Oriolo (1997); 7. Southern Rhaetian Alps (Nonsberger Alps, Bresimo valley). *Nardetum alpigenum*: table C (19 relevés) in Orlandi (1985); 8. Western Rhaetian Alps (S. Giacomo valley). *Nardetum alpigenum typicum*: table 31 (rel. 1-18) in Giacomini *et al.* (1962); 9. Feltre Dolomites. *Nardetum alpigenum*: table with 14 relevés, 4 drawn from an unnumbered table at pg. 46 in Pignatti & Pignatti (1983) and 10 from an unnumbered table at pp. 148-149 in Lasen (1983); 10. Western Rhaetian Alps (S. Giacomo valley). *Nardetum alpigenum trifolietosum*: table 31 (rel. 19-31) in Giacomini *et al.* (1962); 11. Southern Rhaetian Alps (Ortler-group, Tonale pass). *Nardetum alpigenum*: unnumbered synoptic table (7 relevés) at pp. 74-75 in Pedrotti (1963); 12. North-Eastern Alps (Allgäuer Alps). *Aveno versicoloris-Nardetum*: table 39 (rel. 1-11) in Herter (1990); 13. Bernese pre-Alps (Schinigeplatte). *Sieversio-Nardetum strictae*: table 7 (6 relevés) in Lüdi (1948); 14. Carnic Alps. *Sieverso-Nardetum strictae* high-montane form: table 4 (rel. 1-10) in Poldini & Oriolo (1997); 15. Savoy pre-Alps (Giffre basin). *Nardetum strictae*: unnumbered table (8 relevés) pp. 680-681 in Guinochet (1939); 16. Southern Rhaetian Alps (Orobie Alps). *Nardetum alpigenum*: table with 12 relevés, 10 belonging to table 10 in Andreis & Rodondi (1984) and 2 drawn from Pirola (1984); 17. Carnic Alps. *Homogyno alpinae-Nardetum*: table 2 (17 relevés) in Poldini & Oriolo (1997); 18. North-Eastern Alps (Bavarian Alps). *Nardetum alpigenum*: table 115

col. 2 (12 relevés) in Oberdorfer (1978); 19. North-Eastern Alps (Styrian Alps, Hochschwab group). *Sieversio-Nardetum strictae*: table 22 (21 relevés) in Dirnböck *et al.* (1999); 20. Southern Rhaetian Alps (Rendena valley). *Nardetum alpigenum*: table with 20 relevés, 16 drawn from table 9 and 4 from table 11 in Bezzi *et al.* (1984); 21. North-Eastern Alps (Allgäuer Alps). *Geo montani-Nardetum strictae*: table 39 (rel. 12-27) in Herter (1990); 22. Garda pre-Alps (Mt. Baldo). *Nardetum alpigenum trifolietosum*: table 5 (11 relevés) in Gerdol & Piccoli (1980); 23. Swiss Jura. *Nardetum jurassicum*: table 15 (rel. 1-25) in Beguin *et al.* (1972); 24. Western Julian Alps. *Nardetum alpigenum trifolietosum*: Table 1 (13 relevés) in Lausi *et al.* (1981); 25. Ligurian Alps. *Nigritello cornelianae-Nardetum strictae*: table 6 (29 relevés) in Barbero (1970); 26. Maritime Alps (Tinée valley). *Nardetum alpigenum pedicularetosum incarnatae*: table 25 (16 relevés) in Lacoste (1975); 27. Cottian Alps (Grana valley). Community of *Nardus stricta* and *Poa alpina*: unnumbered table (7 relevés) at pp. 239-240 in Mondino (1964); 28. Northern Apennines. *Violo ferrarinii-Nardetum strictae typicum*: table IV (15 relevés, from 1 to 19) in this paper; 29. Northern Apennines. *Violo ferrarinii-Nardetum strictae luzuletosum multiflorae*: table VI (24 relevés, from 13 to 66) in this paper; 30. Northern Apennines. *Violo ferrarinii-Nardetum strictae phleetosum rhaetici*: table VII (17 relevés) in this paper; 31. Northern Apennines. *Violo ferrarinii-Nardetum strictae crepidetosum glabrescentis*: table V (24 relevés) in this paper; 32. Northern Apennines (Pratomagno massif). *Carlino caulescentis-Nardetum strictae*: table II (20 relevés) in this paper from Viciani & Gabellini (2000); 33. Central Apennines (Sibillini Mountains). *Nardetum apenninicum polygonetosum*: table 6 (rel. 10-25) in Cortini Pedrotti *et al.* (1973); 34. Central Apennines (Sibillini Mountains). *Nardetum apenninicum filipenduletosum*: table 6 (rel. 26-40) in Cortini Pedrotti *et al.* (1973); 35. Central Apennines (Macerata Apennines). *Poo violaceae-Nardetum strictae festucetosum circummediterraneae*: table 4 (8 relevés) in Catorci *et al.* (2007); 36. Central Apennines (Reatini Mountains). *Agrostio tenuis-Nardetum strictae*: table 1 (rel. 1-22) in Gigli *et al.* (1991); 37. Central Apennines (Gran Sasso d'Italia). *Poo violaceae-Nardetum strictae*: table 10 (9 relevés) in Biondi *et al.* (1999); 38. Central Apennines (Mt. Greco). *Poo violaceae-Nardetum strictae festucetosum circummediterraneae*: table 4 (7 relevés) in Di Pietro *et al.* (2005); 39. Central Apennines (Reatini Mountains). *Luzulo italicae-Nardetum strictae*: table 1 (rel. 23-32) in Gigli *et al.* (1991); 40. Central Apennines (Simbruini Mountains). *Luzulo italicae-Nardetum strictae*: table 20 (19 relevés) in De Sillo *et al.* (2012); 41. Southern Apennines (Sirino-Papa massif). *Plantagini serpentinae-Nardetum strictae*: table 2 (6 relevés) in Tomaselli *et al.* (2003); 42. Central Apennines (Gran Sasso d'Italia). *Luzulo italicae-Nardetum strictae caricetosum kitaibelianae*: table 8 (rel. 7-11) in Biondi *et al.* (1999); 43. Southern Apennines (Mt. Pollino). *Nardo-Luzuletum pindicae*: table 1 (rel. 1-11) in Tomaselli *et al.* (2003); 44. Carpathians (Low Tatras). *Nardetum montanum*: table 2 (11 relevés) in Sillinger (1933).

Electronic Appendices

Appendix 1. Carlino caulescentis-Nardetum strictae. D: differential species against the other associations of the Nardo-Agrostion tenuis. In the bottom of the table are reported the rare species with + or *r* in less than three relevés.
Appendix 2. Violo ferrarinii-Nardetum strictae subass. typicum (rel. 1–19: typical variant; rel. 2–88: variant of *Carex sempervirens*). In bold types phi values of the differential species of the second variant. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; VD: differential species of variant; TC: territorial characteristic species. In the bottom of the table are reported the rare species with + or *r* in less than three relevés.
Appendix 3. Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; SAD: differential species of subassociation; TC: territorial characteristic species. In the bottom of the table are reported the rare species with + or *r* in less than three relevés.
Appendix 4. Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae (rel. 13–66: typical variant; rel. 51–58: variant of *Potentilla erecta*). In bold phi values of the differential species of the second variant. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; TC: territorial characteristic species. In the bottom of the table are reported the rare species with + or *r* in less than three relevés.
Appendix 5. Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; SAD: differential species of subassociation. In the bottom of the table are reported the rare species with + or *r* in less than three relevés.

Appendix data associated with this article can be found in the online version at
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Electronic Appendix 5. Violo ferrarinii-Nardetum strictae subass. phleetosum rhaetici. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; SAD: differential species of subassociation. In the bottom of the table are reported the rare species with + or r in less than three relevés.

Relevé n.	67	104	105	106	107	108	76	112	113	96	97	98	99	100	101	102	103
Site	PU	TA	TA	TA	CV	CU	CF	CS	PE	FC	SA	GA	FG	FC	PA	UM	PS
Elevation (m a.s.l.)	1700	1650	1630	1620	1620	1800	1570	1690	1620	1640	1680	1700	1400	1650	1730	1600	1650
Aspect (°)	W	NW	WNW	NE	-	-	NNE	W	NNW	N	NW	N	N	N	S	N	N
Slope angle (°)	5	5	15	25	-	-	20	5	5	10	10	10	5	15	10	10	10
Relevé area (mq)	40	10	8	30	10	50	100	10	100	15	15	10	15	10	15	15	10
Vegetation cover (%)	100	90	80	100	100	85	100	100	100	100	100	100	100	100	100	100	100
N. of species	12	20	20	18	9	15	21	16	22	18	20	22	15	15	13	17	18
N. of rare species	1	7	5	4	1	-	8	3	8	-	-	-	1	2	-	-	-
Violo ferrarinii-Nardetum strictae																	
Nardion strictae																	
Nardus stricta (ALD)	5	3	4	3	3	4	3	.	1	4	5	4	5	3	4	2	3
Festuca rubra subsp. commutata (ALD)	2	2	1	.	2	1	.	4	2	1	2	2	2	2	+	2	.
Potentilla aurea	.	.	.	+	.	.	.	.	.	+	+	.	.	+	.	1	+
Geum montanum	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	2	2
Leontodon helveticus	.	.	.	+	1	+	.	.	+	.	.	.	.	.	.	.	.
Gentiana acaulis	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	+
Gnaphalium sylvaticum (ALD)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Plantago alpina	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Viola ferrarinii	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Subass. phleetosum rhaetici																	
Phleum rhaeticum	+	+	+	+	2	+	1	+	1	+	+	1	+	1	1	1	.
Trifolium pratense	+	1	1	1	.	+	1	+	1	.	1	+	1	.	.	+	1
Alchemilla gr. vulgaris	r	1	1	1	.	.	.	.	.	1	1	1	1	1	1	1	2
Lotus corniculatus	+	+	+	+	+	1	1	.	.	1	1	1	1	.	.	.	.
Ranunculus pollinensis	r	+	+	.	.	.	.	.	.	.	.	.	.	2	+	.	+
Viola reichenbachiana	.	.	.	.	.	.	.	.	.	1	+	1	+	.	+	+	.
Gentiana verna	.	+	+	.	.	.	.	.	.	+	.	+	.	.	.	.	1
Caricetalia and Caricetea curvulae																	
Anthoxanthum odoratum subsp. nipponicum	.	.	.	.	.	+	.	.	.	1	1	+	+	2	1	2	+
Alchemilla gr. alpina	+	.	+	.	.	.	.	+	1	.	1	1	.	.	.	.	.
Agrostis rupestris	.	+	+	.	.	.	.	.	.	.	.	.	.	1	.	.	1
Botrychium lunaria (SAD)	.	.	.	.	.	.	.	.	.	.	+	+	.	1	.	.	+
Euphrasia minima	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	.
Armeria marginata	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Centaurea uniflora subsp. nervosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Euphrasia alpina	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Hieracium alpicola	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Companions																	
Nardetea strictae																	
Luzula multiflora	.	.	.	.	.	+	1	+	1	1	2	2	1	1	1	+	+
Potentilla erecta	.	.	.	.	.	.	1	1	.	.	1	1	1	.	+	.	.
Antennaria dioica	.	.	.	.	.	.	.	.	.	1	.	+	.	.	1	+	1
Hieracium pilosella	.	.	.	.	.	.	.	.	.	1	+	2	+	.	.	.	.
Dianthus deltoides	.	.	.	.	.	+	+	.	1	.	.	.	.	.	.	.	.
Meum athamanticum	.	.	.	.	.	r	1	.	.	1	.	.	.	.	.	.	.
Molinio-Arrhenatheretea																	
Sagina glabra	.	+	+	+	+	+	.	.	.	.	1	1	1	.	+	+	+
Poa alpina	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Achillea millefolium	.	+	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.
Agrostis capillaris	.	.	.	1	.	.	.	2	2	.	.	.	.	.	.	.	.
Other companions																	
Hypericum richeri	+	.	+	1	.	.	.	1	.	.	.	1	.	1	1	.	.
Thymus praecox subsp. polytrichus	+	.	.	.	.	.	+	+	+	+	.	.	+	.	.	.	1
Vaccinium myrtillus	.	.	.	+	.	.	+	1	+	.	1	+	.	.	.	+	.
Crepis aurea subsp. glabrescens	.	3	1	2	+	+	.	.	.	.	.	.	.	.	.	.	.
Deschampsia flexuosa	r	.	.	.	.	.	.	+	.	2	+	+	.	.	.	.	.
Rumex acetosella	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	.	+
Campanula scheuchzeri	.	.	.	+	+	.	.	.	.	1	.	.	.	.	+	.	.
Cirsium morisianum	.	.	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.
Phyteuma scorzonerifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+

Rare species: Carlina acaulis subsp. *caulescens*: rel. 106 (+), rel. 113 (1); *Leontodon hispidus*: rel. 104 (+), rel. 105 (+); *Phyteuma orbiculare*: rel. 67 (r), rel. 104 (r); *Pimpinella saxifraga* subsp. *alpestris*: rel. 106 (r), rel. 113 (+); *Plantago maritima* subsp. *serpentina*: rel. 99 (1), rel. 76 (1); *Stellaria graminea*: rel. 112 (+), rel. 113 (2); *Taraxacum aemilianum*: rel. 104 (+), rel. 105 (r); *Veronica officinalis*: rel. 112 (1), rel. 113 (1); *Ajuga reptans*: rel. 76 (+); *Bistorta officinalis*: rel. 76 (+); *Brachypodium genuense*: rel. 105 (+); *Carduus carlinifolius*: rel. 104 (+); *Carex leporina*: rel. 113 (+); *Carum apuanum*: rel. 105 (+); *Cyanus triumfetti*: rel. 76 (1); *Cerastium arvense* subsp. *suffruticosum*: rel. 76 (+); *Cerastium holosteoides*: rel. 113 (r); *Cirsium bertolonii*: rel. 106 (+); *Coeloglossum viride*: rel. 100 (+); *Crocus vernus*: rel. 100 (+); *Dianthus sylvestris*: rel. 112 (1); *Euphorbia cyparissias*: rel. 76 (1); *Festuca violacea* subsp. *puccinellii*: rel. 105 (+); *Galium anisophyllon*: rel. 113 (+); *Leucanthermum heterophyllum*: rel. 106 (+); *Polygonum viviparum*: rel. 104 (1); *Ranunculus apenninus*: rel. 76 (+); *Rumex nebroides*: rel. 113 (2); *Serratula tinctoria* subsp. *macrocephala*: rel. 76 (+); *Soldanella alpina*: rel. 104 (+); *Taraxacum officinale*: rel. 107 (+); *Trifolium thalii*: rel. 104 (+).

Electronic Appendix 4. Violo ferrarinii-Nardetum strictae subass. luzuletosum multiflorae (rel. 13-66: typical variant; rel. 51-58: variant of Potentilla erecta). In bold phi values of the differential species of the second variant. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; TC: territorial characteristic species. In the bottom of the table are reported the rare species with + or r in less than three relevés.

Relevé n.	13	47	44	49	50	70	71	14	78	72	73	74	75	45	46	48	54	110	111	62	63	64	65	66	51	52	61	69	53	77	109	55	57	59	60	56	58	phi
Site	PC	AQ	CA	NU	VP	NU	NU	AL	AN	PA	PI	PA	PU	LG	SP	AL	SC	CS	CS	VE	VE	VE	VE	VE	FO	FO	TO	PI	TO	GV	CE	NU	GV	CM	PE	PE	PE	
Elevation (m a.s.l.)	1810	1630	1690	1720	1720	1640	1640	1580	1600	1520	1520	1500	1500	1710	1600	1670	1640	1775	1720	1600	1630	1620	1640	1700	1800	1820	1720	1610	1770	1675	1650	1690	1670	1540	1680	1620	1670	
Aspect (°)	-	-	NE	NW	-	-	N	-	N	N	N	N	N	-	-	SW	W	SW	SW	W	WNW	WNW	W	NW	S	W	SW	NE	SSW	SSE	W	SW	W	SW	SE	S	SW	
Slope angle (°)	-	-	15	5	-	-	5	-	5	5	5	5	5	-	-	5	15	10	20	15	20	10	20	10	25	15	20	15	\5	25	10	20	15	15	20	20	15	
Relevé area (mq)	30	50	30	80	70	40	20	50	15	100	100	100	100	100	70	60	100	10	10	60	30	80	100	20	100	50	50	100	100	100	50	100	100	50	50	100	70	
Vegetation cover (%)	100	100	95	100	100	100	100	100	100	100	100	95	95	95	100	100	100	90	100	100	100	60	100	95	100	90	100	100	95	85	95	100	100	100	100	100	100	
N. of species	17	15	22	17	20	15	8	12	20	22	24	14	16	30	31	19	29	17	22	20	22	25	20	22	25	19	20	12	30	26	22	23	23	21	29	18	28	
N. of rare species	1	-	-	1	-	-	-	-	1	1	1	1	1	2	6	2	2	1	4	-	-	1	-	-	2	2	-	4	3	3	3	2	1	2	1	1	5	
Violo ferrarinii-Nardetum strictae																																						
Nardion strictae																																						
Nardus stricta (ALD)	4	3	2	2	3	3	4	3	4	3	3	4	4	4	2	4	4	+	1	4	4	5	4	4	4	3	3	5	1	2	2	4	4	2	3	4	3	
Festuca rubra subsp. commutata (ALD)	1	1	3	2	1	2	1	2	2	3	3	2	2	1	3	1	2	4	3	1	+	1	.	+	1	1	1	2	3	+	3	2	2	3	3	2	2	
Geum montanum	1	2	1	1	1	.	+	3	+	2	2	1	1	1	1	2	1	2	1	1	+	1	+	1	+	+	+	.	1	2	1	1	.	+	+	1	.	
Viola ferrarinii	.	+	1	r	1	+	.	.	.	.	.	.	.	.	+	.	+	1	+	+	+	+	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	
Gentiana acaulis	.	.	.	.	+	.	.	.	.	.	.	.	.	+	+	.	r	.	.	.	+	.	+	.	.	.	.	.	+	.	.	1	.	1	1	+	+	
Leontodon helveticus	+	r	.	.	+	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	
Potentilla aurea	1	+	.	+	.	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Plantago alpina	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	+	+	.	.	.	.	.	.	.	
Pedicularis tuberosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	.	+	.	r	
Trifolium alpinum	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	
Gnaphalium sylvaticum (ALD)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	
Subass. luzuletosum multiflorae																																						
Luzula multiflora	+	+	1	1	+	1	+	1	+	.	.	.	.	1	1	1	1	+	r	+	+	+	+	+	1	+	.	.	1	+	.	2	2	1	2	1	2	
Deschampsia flexuosa	+	2	1	2	2	.	.	.	.	.	.	.	.	2	1	2	2	1	2	1	1	1	+	.	2	2	2	+	2	+	+	2	2	1	2	2	3	
Brachypodium genuense	.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	2	2	+	+	+	+	+	.	.	.	.	.	.	+	.	+	.	.	+	.	
Polygala alpestris	.	.	+	+	.	+	.	+	+	+	+	.	.	+	+	r	+	.	.	.	.	+	+	+	+	.	.	.	+	1	.	+	+	.	+	.	1	
Genista tinctoria	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	+	1	.	.	2	.	.	.	.	1	+	2	2	+	+	
Variant of Potentilla erecta																																						
Potentilla erecta	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	+	+	.	.	.	.	.	.	.	.	1	+	+	+	+	+	1	+	.	1	+	***69.3***
Juniperus communis subsp. alpina	+	.	.	.	.	.	.	.	+	+	2	+	2	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	2	+	+	.	.	.	+	.	.	***41.4***
Plantago maritima subsp. serpentina	.	.	+	.	.	.	.	.	1	.	.	.	.	+	1	.	+	r	.	.	.	.	.	.	.	.	+	.	.	.	.	1	+	1	1	+	+	***43.9***
Dianthus sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	1	+	+	1	1	1	+	1	***85.6***
Hieracium pilosella	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	+	+	+	1	***45.4***
Calluna vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	1	.	.	+	+	.	.	***54.8***
Caricetalia and Caricetea curvulae																																						
Anthoxanthum odoratum subsp. nipponicum	.	+	1	.	.	.	.	+	+	+	+	r	r	1	2	+	1	1	2	+	+	r	+	+	2	+	1	r	2	.	1	+	2	.	+	.	.	
Alchemilla gr. alpina	.	+	.	1	2	+	.	.	+	+	+	+	+	+	+	+	+	2	1	1	1	1	2	1	1	3	.	.	1	+	2	.	+	+	1	.	.	
Phyteuma hemisphaericum	.	.	+	+	1	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	r	.	.	.	+	.	.	.	.	.	+	.	+	
Carex sempervirens (TC)	1	.	.	+	2	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	
Festuca riccerii	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	
Agrostis rupestris	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	
Euphrasia minima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	
Centaurea uniflora subsp. nervosa	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Juncus trifidus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	
Euphrasia alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	
Festuca paniculata subsp. paniculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	
Luzula lutea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	
Companions																																						
Nardetea strictae																																						
Dianthus deltoides	+	.	1	.	.	+	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Veronica officinalis	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	+	.	.	r	r	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	
Antennaria dioica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	+	.	.	r	.	.	.	+	.	
Carex leporina	.	.	.	.	.	+	2	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Molinio-Arrhenatheretea																																						
Poa alpina	+	+	+	.	+	1	+	.	.	.	.	.	.	+	+	.	+	+	.	+	+	1	1	+	.	.	.	.	.	.	.	.	.	.	+	.	.	
Lotus corniculatus	.	.	.	+	.	.	.	.	+	+	+	.	.	+	+	.	+	.	.	.	+	.	.	1	1	.	1	.	+	+	.	.	.	.	.	.	2	
Bistorta officinalis	+	+	+	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	r	+	.	.	.	.	.	.	.	1	1	+	+	.	.	
Trifolium pratense	.	.	.	+	.	r	.	+	+	+	+	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Agrostis capillaris	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	+	.	2	.	.	.	+	.	.	
Phleum rhaeticum	.	.	.	.	.	.	.	.	.	+	+	.	.	+	+	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Crocus vernuus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	+	.	.	+	1	
Sagina glabra	.	.	+	.	.	.	.	+	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Achillea millefolium	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	.	.	.	.	.	1	
Alchemilla gr. vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	
Cerastium holosteoides	.	.	.	.	.	+	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	
OTHER COMPANIONS																																						
Vaccinium myrtillus	.	.	1	.	+	.	.	+	+	+	+	1	1	+	+	+	2	+	.	1	+	+	+	+	2	1	2	2	1	+	.	1	2	.	1	1	+	
Hypericum richeri	+	+	1	+	+	.	.	.	.	+	+	+	+	+	.	+	+	.	.	1	1	+	1	+	.	.	2	.	+	2	r	1	1	+	1	1	+	
Thymus praecox subsp. polytrichus	.	.	.	.	.	.	.	+	1	+	+	+	+	+	.	.	.	.	+	+	1	+	1	+	.	.	+	+	+	r	.	+	1	+	.	.	+	
Carlina acaulis subsp. caulescens	.	.	.	.	.	1	.	.	.	+	+	+	+	1	+	.	.	.	+	.	.	.	+	1	+	.	1	.	+	+	.	.	.	.	+	.	.	
Pimpinella saxifraga	.	.	.	.	.	.	.	+	.	.	.	+	+	.	r	r	.	.	+	+	1	1	1	1	.	.	.	.	r	+	.	.	.	.	.	.	.	
Galium anisophyllon	.	.	+	1	+	+	+	.	.	.	.	.	.	+	+	+	.	.	.	+	+	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	
Vaccinium gaultherioides	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	2	1	2	1	1	.	.	.	1	.	1	+	.	
Campanula scheuchzeri	.	.	+	.	.	+	.	.	.	.	.	.	.	+	+	.	+	.	+	+	.	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	
Cerastium arvense subsp. suffruticosum	.	.	.	.	.	.	.	.	.	+	+	.	.	+	+	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	+	.	+	
Luzula sieberi	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	.	.	.	r	.	.	.	.	.	.	.	.	+	2	.	.	.	.	
Anemone nemorosa	.	.	.	.	+	.	.	.	.	1	1	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	
Homogyne alpina	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	
Seseli libanotis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	+	
Cruciata glabra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Dactylorhiza sambucina	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	
Pulsatilla alpina subsp. millefoliata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	

Rare species: Carex macrolepis: rel. 51 (+), rel. 69 (+); *Cirsium morisianum*: rel. 46 (r), rel. 64 (+); *Galium mollugo*: rel. 51 (+), rel. 58 (+); *Meum athamanticum*: rel. 48 (+), rel. 69 (+); *Minuartia verna*: rel. 54 (+), rel. 109 (+); *Ranunculus apenninus*: rel. 46 (+), rel. 72 (+); *Rumex acetosella*: rel. 55 (+), rel. 57 (1); *Rumex nebroides*: rel. 45 (+), rel. 48 (+); *Taraxacum officinale*: rel. 74 (r), rel. 75 (r); *Veronica serpyllifolia*: rel. 56 (+), rel. 58 (+); *Ajuga reptans*: rel. 109 (+); *Asperula aristata* subsp. *oreophila*: rel. 111 (+); *Bunium bulbocastanum*: rel. 77 (+); *Carex caryophyllea*: rel. 54 (+); *Carex pallescens*: rel. 78 (1); *Carum apuanum*: rel. 69 (+); *Cirsium bertolonii*: rel. 46 (+); *Colchicum alpinum*: rel. 109 (+); *Crepis aurea* subsp. *glabrescens*: rel. 46 (1); *Danthonia decumbens*: rel. 110 (+); *Deschampsia caespitosa*: rel. 46 (+); *Festuca alfrediana* subsp. *ferrariniana*: rel. 53 (+); *Fragaria vesca*: rel. 77 (+); *Galium lucidum*: rel. 111 (+); *Gentianella campestris*: rel. 52 (+); *Hieracium murorum*: rel. 53 (r); *Hypericum montanum*: rel. 69 (r); *Leucanthemum vulgare*: rel. 59 (+); *Lilium martagon*: rel. 58 (r); *Narcissus poeticus*: rel. 59 (+); *Orobanche* sp.: rel. 111 (r); *Plantago atrata* subsp. *fuscescens*: rel. 111 (1); *Rhinanthus serotinus*: rel. 45 (+); *Rubus idaeus*: rel. 55 (r); *Sanguisorba officinalis*: rel. 13 (1); *Silene nutans*: rel. 58 (+); *Silene rupestris*: rel. 53 (+); *Stellaria graminea*: rel. 49 (+); *Swertia perennis*: rel. 52 (+); *Traunsteinera globosa*: rel. 73 (r); *Trifolium medium*: rel. 58 (1); *Trifolium repens*: rel. 77 (+); *Trifolium thalii*: rel. 46 (r); *Trollius europaeus*: rel. 60 (+).

Electronic Appendix 3. Violo ferrarinii-Nardetum strictae subass. crepidetosum glabrescentis. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; SAD: differential species of subassociation; TC: territorial characteristic species. In the bottom of the table are reported the rare species with + or r in less than three relevés.

Relevé n.	4	5	27	30	28	31	32	33	34	25	26	29	35	36	37	43	22	23	24	38	39	40	42	41
Site	GI	GI	PR	PR	LA	PR	PR	PR	PR	GI	GI	PR	CU	CU	PR	BR	RO	GI	GI	LG	GI	CU	GI	CU
Elevation (m a.s.l.)	1770	1770	1850	1780	1830	1870	1840	1830	1860	1770	1760	2020	1870	1900	2030	1730	1860	1760	1760	1950	1950	2010	1700	2020
Aspect (°)	WSW	WSW	N	N	-	NW	NE	NE	NE	-	-	N	-	N	W	-	-	-	-	-	-	N	-	-
Slope angle (°)	25	25	5	5	-	20	15	10	5	-	-	8	-	8	5	-	-	-	-	-	-	5	-	-
Relevé area (mq)	10	20	20	10	10	20	10	10	20	5	5	10	30	5	10	10	10	5	8	10	10	5	20	10
Vegetation cover (%)	90	90	100	100	80	100	100	100	100	100	100	95	100	90	90	90	90	100	100	95	100	90	100	90
N. of species	18	15	13	13	11	8	16	17	12	6	6	13	13	11	9	11	5	6	7	9	7	9	13	17
N. of rare species	2	1	-	-	-	1	-	3	1	1	-	2	1	1	-	-	1	-	-	-	-	-	2	5
Violo ferrarinii-Nardetum strictae																								
Nardion strictae																								
Nardus stricta (ALD)	2	4	5	3	4	3	4	4	3	5	5	5	4	4	4	5	4	5	5	5	5	4	4	4
Festuca rubra subsp. commutata (ALD)	1	1	1	3	1	3	1	1	2	.	.	1	2	+	1	1	.	.	.	1	1	1	1	1
Plantago alpina (SAD)	+	+	1	1	1	1	1	1	1	+	.	+	1	1	1	1	.	.	.	.	.	+	+	1
Geum montanum	1	1	1	.	+	+	+	1	1	.	+	.	+	.	.	.	1	+	+	+	1	1	+	1
Potentilla aurea	+	.	.	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	r	+	.	+	+
Viola ferrarinii	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Gentiana acaulis	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leontodon helveticus	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Subass. crepidetosum glabrescentis																								
Poa alpina	+	1	+	1	+	+	1	1	1	1	1	+	+	+	1	+	+	1	1	1	1	+	+	+
Crepis aurea subsp. glabrescens	+	1	+	+	1	.	1	+	+	+	+	+	1	+	+	+	.	.	+	+	+	1	r	2
Luzula alpinopilosa	.	.	1	+	.	.	+	+	+	+	+	+	+	2	1	.	.	.	.	.	.	.	.	.
Caricetalia and Caricetea curvulae																								
Alchemilla gr. alpina	+	+	.	+	+	+	+	1	1	.	+	+	.	.	.	+	.	+	+	.	.	.	.	+
Carex sempervirens (TC)	2	1	+	+	.	.	+	+	.	.	.	.	.	.	.	.	1	+	+	.	+	.	.	+
Phyteuma hemisphaericum	1	1	+	+	+	+	.	.	.	.	.	+	.	r	+	.	.	.	.	.	.	.	+	.
Juncus trifidus	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agrostis rupestris	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.
Anthoxanthum odoratum subsp. nipponicum	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia minima	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Companions																								
Nardetea strictae																								
Carex leporina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	1	.
Molinio-Arrhenatheretea																								
Phleum rhaeticum	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	.	+	.	+	2	.
Sagina glabra	.	.	.	.	+	.	.	.	+	.	.	.	.	1	.	+	.	.	.	1	.	.	.	+
Trifolium pratense	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	+	+
Deschampsia cespitosa	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.
Other companions																								
Vaccinium gaultherioides	+	+	+	1	+	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	+	+	+	+	+	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Hypericum richeri	+	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Brachypodium genuense	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Gnaphalium supinum	.	.	+	+	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Rare species: Campanula scheuchzeri: rel. 31 (r), rel. 33 (+); *Carex foetida*: rel. 29 (+), rel. 36 (+); *Polygala alpestris*: rel. 4 (+), rel. 5 (+); *Sedum alpestre*: rel. 33 (+), rel. 34 (+); *Acinos alpinus*: rel. 41 (+); *Cirsium morisianum*: rel. 41 (+); *Crocus vernus*: rel. 22 (+); *Cryptogramma crispa*: rel. 25 (+); *Deschampsia flexuosa*: rel. 29 (+); *Galium anisophyllon*: rel. 41 (+); *Juniperus communis* subsp. *alpina*: rel. 4 (+); *Lotus corniculatus*: rel. 42 (+); *Ranunculus apenninus*: rel. 42 (r); *Rumex nebroides*: rel. 41 (+); *Soldanella alpina*: rel. 33 (+); *Thymus praecox* subsp. *polytrichus*: rel. 41 (+);

Electronic Appendix 2. Violo ferrarinii-Nardetum strictae subass. typicum (rel. 1-19: typical variant; rel. 2-88: variant of Carex sempervirens). In bold types phi values of the differential species of the second variant. ALD: differential species of the Nardion strictae against the other alliances of the Caricetalia curvulae; VD: differential species of variant; TC: territorial characteristic species. In the bottom of the table are reported the rare species with + or r in less than three relevés.

Relevé n.	1	6	7	9	17	10	11	8	12	20	21	15	16	18	19	2	3	114	68	79	80	82	81	90	83	84	92	93	94	95	89	91	85	86	87	88	**phi**
Site	CU	CI	PC	PC	SP	PC	PC	PC	PC	LG	CS	BR	TP	BO	MA	FE	FO	TP	FC	MT	BG	SI	BG	SI	BG	BG	BG	BG	BG	BG	NS	CP	BG	BO	GI	BO	
Elevation (m a.s.l.)	1830	1900	1860	1840	1680	1790	1830	1820	1790	1920	1650	1680	1730	1780	1830	1750	1800	1687	1630	1670	1680	1770	1620	1780	1660	1680	1690	1680	1640	1610	1820	1850	1640	1650	1770	1680	
Aspect (°)	SSW	NW	N	N	-	NW	NNW	-	W	-	NE	N	-	-	-	WNW	SW	-	-	-	-	-	NNE	-	NE	NE	NNE	ENE	NNW	NNE	-	N	N	-	N	ESE	
Slope angle (°)	5	20	5	10	-	5	5	-	5	-	5	10	-	-	-	20	30	-	-	-	-	-	10	-	25	10	20	5	10	15	-	2	5	-	10	5	
Relevé area (mq)	10	50	30	50	30	50	30	30	30	20	80	20	20	10	10	10	40	50	5	10	10	20	20	20	100	50	25	50	40	80	10	5	25	20	30	15	
Vegetation cover (%)	100	90	100	100	100	100	95	100	100	100	90	100	100	100	100	95	95	100	100	100	90	100	100	100	100	100	100	85	80	100	100	90	100	100	100	100	
N. of species	20	19	25	26	15	20	23	23	18	9	17	16	22	14	11	26	12	14	12	18	14	11	14	14	17	18	17	18	21	17	16	16	13	17	13	12	
N. of rare species	-	2	4	-	-	-	-	1	1	-	2	2	3	1	-	3	1	-	1	1	-	-	-	-	-	-	-	2	2	1	-	-	-	-	-	-	
Violo ferrarinii-Nardetum strictae subass. Nardion strictae																																					
Nardus stricta (ALD)	3	3	2	3	5	4	3	3	4	5	4	4	4	5	4	3	5	2	5	4	4	5	4	5	3	4	3	3	2	3	5	4	5	5	5	5	
Festuca rubra subsp. commutata (ALD)	1	.	3	2	1	2	1	1	1	1	1	2	1	1	1	2	1	4	1	1	2	1	2	1	2	1	1	1	+	1	+	.	+	+	+	1	
Geum montanum	3	2	3	2	1	1	+	1	2	2	1	2	1	1	1	2	1	+	.	1	+	+	.	+	+	+	.	.	+	.	+	2	1	+	1	+	
Leontodon helveticus	.	+	+	+	+	+	+	+	.	.	.	+	+	r	2	1	.	.	+	+	+	1	1	+	+	1	1	+	+	+	1	1	.	.	.	.	
Potentilla aurea	+	+	+	1	+	1	+	1	1	.	+	r	+	.	+	+	.	.	.	+	+	.	.	.	.	.	+	.	.	.	r	.	.	.	+	.	
Plantago alpina	1	1	1	1	2	+	1	.	.	.	.	.	1	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Viola ferrarinii	+	.	+	+	+	1	1	+	.	.	.	.	.	.	.	2	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	
Trifolium alpinum	+	.	1	+	.	+	+	+	1	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Pedicularis tuberosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Solidago virgaurea subsp. minuta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Variant of Carex sempervirens																																					
Vaccinium gaultherioides	+	+	.	+	.	.	+	1	+	.	.	.	.	.	.	+	.	.	.	.	1	+	1	+	1	1	2	3	2	2	+	+	+	1	+	1	***42.0***
Potentilla erecta	.	.	.	1	+	.	+	+	+	.	.	.	+	.	.	.	.	.	+	.	+	+	1	+	1	1	1	1	1	1	1	1	1	1	1	1	***42.0***
Plantago maritima subsp. serpentina	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	1	+	1	+	r	1	+	+	+	+	1	.	+	.	+	1	.	***64.3***
Deschampsia flexuosa	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	+	1	.	.	+	+	+	2	1	1	.	.	.	.	***47.8***
Caricetalia and Caricetea curvulae																																					
Carex sempervirens (TC)	+	2	.	.	.	.	+	+	+	.	.	.	.	1	+	3	2	2	.	+	1	+	1	+	2	1	1	1	2	2	+	2	1	1	1	1	***55.3***
Anthoxanthum odoratum subsp. nipponicum (V	.	.	.	1	1	.	.	.	.	.	.	+	1	+	.	+	r	1	.	.	+	+	+	1	+	+	1	+	+	+	.	1	1	1	+	1	***53.8***
Alchemilla gr. alpina	.	+	+	+	+	.	.	.	.	+	1	r	.	+	.	+	.	.	+	1	+	.	.	.	.	+	+	+	+	.	+	+	+	r	.	.	
Phyteuma hemisphaericum	+	1	1	1	.	1	2	+	.	.	.	.	.	+	+	1	+	r	.	.	.	.	.	.	+	+	+	+	+	+	.	+	.	.	.	.	
Euphrasia minima	+	+	.	+	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Agrostis rupestris	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	
Juncus trifidus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	
Luzula lutea	.	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Centaurea uniflora subsp. nervosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Euphrasia alpina	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Festuca paniculata subsp. paniculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	
Hieracium alpicola	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Companions																																					
Nardetea strictae																																					
Carex pallescens	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	1	+	+	1	.	+	+	.	+	.	.	.	.	+	1	.	.	
Luzula multiflora	.	.	+	+	.	+	+	+	1	+	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Carex pilulifera	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	+	.	.	.	.	.	.	.	.	.	.	1	.	+	
Antennaria dioica	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	
Dianthus deltoides	.	.	.	.	.	1	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Ranunculus apenninus	.	.	+	1	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Hieracium pilosella	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Carex leporina	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Molinio-Arrhenatheretea																																					
Deschampsia cespitosa	.	.	.	+	+	+	.	1	+	+	2	.	+	1	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	+	.	.	1	+	+	+	
Phleum rhaeticum	+	.	+	+	.	.	.	+	.	+	1	+	+	1	1	.	.	1	1	+	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	
Bistorta officinalis	+	.	+	+	+	.	.	+	1	.	+	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	+	
Sagina glabra	.	+	+	+	2	+	+	.	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Poa alpina	.	.	1	1	+	+	+	+	.	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	
Sanguisorba officinalis	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	
Trifolium pratense	.	.	+	r	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Other companions																																					
Vaccinium myrtillus	+	+	+	+	1	+	+	+	+	+	+	+	.	r	.	1	+	+	1	1	+	1	+	+	+	1	1	1	+	1	1	+	+	+	+	.	
Hypericum richeri	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.	1	r	r	1	+	.	.	.	.	+	+	.	.	+	+	r	+	.	.	.	.	
Homogyne alpina	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	1	.	.	+	+	
Juniperus communis subsp. alpina	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	+	.	.	.	.	+	.	+	+	1	+	1	+	.	.	.	.	.	.	
Luzula sieberi	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	.	+	.	.	.	.	.	+	.	r	.	.	.	.	+	1	.	r	.	r	
Vaccinium vitis-idaea	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	+	.	.	
Galium anisophyllon	.	+	1	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.																		
Crepis aurea subsp. glabrescens	.	1	.	.	.	+	2	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Carlina acaulis subsp. caulescens	.	.	.	.	.	r	+	.	.	.	.	+	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Lotus alpinus	.	.	1	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Polygala alpestris	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	
Pimpinella saxifraga	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

Rare species: Agrostis capillaris: rel. 2 (1), rel. 18 (+); *Brachypodium genuense*: rel. 15 (+), rel. 93 (+); *Empetrum hermaphroditum*: rel. 94 (1), rel. 95 (+); *Leontodon hispidus*: rel. 2 (+), rel. 3 (+); *Lotus corniculatus*: rel. 8 (+), rel. 21 (+); *Thymus praecox* subsp. *polytrichus*: rel. 7 (+), rel. 21 (+); *Trifolium repens*: rel. 15 (+), rel. 16 (1); *Alchemilla* gr. *vulgaris*: rel. 7 (+); *Cerastium arvense* subsp. *suffruticosum*: rel. 7 (+); *Cerastium holosteoides*: rel. 16 (+); *Festuca cyrnea*: rel. 68 (1); *Genista tinctoria*: rel. 12 (+); *Gnaphalium supinum*: rel. 6 (+); *Hieracium murorum*: rel. 94 (+); *Luzula alpinopilosa*: rel. 6 (1); *Luzula campestris*: rel. 2 (+); *Rhinanthus serotinus*: rel. 79 (r); *Silene rupestris*: rel. 93 (+); *Taraxacum officinale*: rel. 16 (r); *Trifolium thalii*: rel. 7 (1).

Electronic Appendix 1. Carlino caulescentis-Nardetum strictae. D: differential species against the other associations of the Nardo-Agrostion tenuis. In the bottom of the table are reported the rare species with + or r in less than three relevés.

Relevé n.	115	117	125	126	116	121	120	128	118	123	122	119	124	133	134	127	129	130	131	132	Fr %
Site	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	
Elevation (m a.s.l.)	1460	1520	1440	1510	1520	1570	1530	1450	1510	1450	1470	1580	1490	1500	1530	1370	1360	1500	1480	1450	
Aspect	E	NNE	ENE	NE	NNE	N	NE	E	NE	W	ENE	SW	NE	NE	SW	N	-	-	N	S	
Slope angle (°)	20	20	15	25	20	30	25	5	20	35	40	35	5	10	10	20	-	-	45	30	
Relevé area (mq)	50	100	100	100	100	100	100	50	100	100	100	100	100	100	100	50	50	50	50	50	
Vegetation cover (%)	100	100	100	100	80	100	100	100	100	100	100	100	100	100	100	100	100	90	100	100	
N. of species	16	18	19	25	16	24	20	26	22	22	21	26	26	16	16	22	21	23	23	26	
N. of rare species	1	-	1	4	-	1	-	-	3	-	1	4	2	1	1	1	1	1	2	3	
Carlino caulescentis-Nardetum strictae																					
Cruciata glabra (D)	2	3	+	+	1	1	.	+	1	1	1	+	1	2	1	2	+	1	1	2	95
Carlina acaulis subsp. caulescens (D)	+	+	1	+	+	+	+	+	+	+	1	1	+	.	+	+	+	+	.	1	90
Viola eugeniae (D)	+	.	.	.	.	+	.	r	+	+	+	+	+	.	+	+	.	+	+	r	65
Thymus pulegioides (D)	.	.	+	+	2	+	.	.	1	+	+	+	+	.	+	.	1	.	.	2	60
Carex caryophyllea (D)	+	+	.	.	1	1	+	1	.	.	.	+	+	.	.	2	1	1	.	1	60
Rumex acetosella (D)	+	.	+	+	+	.	+	1	.	.	.	.	+	.	.	1	+	+	+	+	60
Nardo strictae-Agrostion tenuis																					
Agrostis capillaris (D)	.	.	+	+	+	1	+	+	4	1	+	3	+	+	4	.	.	.	.	.	65
Achillea millefolium (D)	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	+	.	.	2	30
Veratrum album subsp. lobelianum (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	10
Nardetalia strictae																					
Nardus stricta	2	4	1	1	3	3	2	4	2	3	2	3	2	5	5	4	4	5	2	1	100
Veronica officinalis	+	1	+	+	1	+	2	+	.	+	1	+	1	+	.	+	.	.	.	.	70
Polygala vulgaris	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	1	1	1	30
Viola canina	.	+	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	20
Nardetea strictae																					
Luzula campestris	1	2	+	1	1	2	2	1	2	1	1	1	+	1	1	1	1	2	1	+	100
Hieracium pilosella	+	+	+	+	3	+	1	1	1	+	+	+	+	.	.	1	+	1	.	.	80
Potentilla erecta	.	.	.	1	.	.	+	.	+	+	+	+	+	3	+	+	1	1	1	1	70
Danthonia decumbens	1	2	1	1	+	+	1	+	2	1	+	+	+	.	.	.	.	.	1	.	70
Calluna vulgaris	.	.	1	+	.	.	+	1	.	+	.	.	.	.	.	.	+	+	.	+	40
Antennaria dioica	.	+	.	1	.	+	+	.	.	+	.	.	.	.	.	.	.	+	.	.	30
Companions																					
Caricetea curvulae																					
Gentiana acaulis	.	.	.	+	.	+	.	+	.	.	.	+	.	.	.	1	+	1	.	.	35
Molinio-Arrhenatheretea																					
Lotus corniculatus	+	1	1	1	2	1	1	1	2	+	1	1	1	+	+	1	2	2	1	1	100
Ajuga reptans	.	+	.	.	+	+	+	+	.	.	+	+	.	.	.	+	.	.	1	.	45
Cerastium holosteoides	.	+	.	.	.	+	+	.	+	.	.	.	+	+	.	.	.	.	.	.	30
Trifolium repens	.	.	.	.	.	+	.	+	.	.	1	.	+	.	.	.	.	.	.	.	20
Trifolium pratense	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	1	15
Crocus vernus	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	15
Trifolium hybridum subsp. elegans	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	15
Alchemilla gr. vulgaris	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	r	15
Other companions																					
Festuca rubra subsp. commutata	1	1	2	1	1	4	4	1	2	3	2	1	2	+	+	2	1	2	2	3	100
Deschampsia flexuosa	4	4	4	3	3	3	3	2	4	4	4	4	4	1	+	.	3	1	4	2	95
Anemone nemorosa	.	+	.	+	.	+	+	2	.	.	.	.	.	.	.	+	+	+	2	.	45
Cerastium arvense subsp. suffruticosum	.	.	.	.	.	.	.	+	.	+	+	.	+	.	+	.	+	+	r	+	45
Galium mollugo	.	.	+	.	.	.	.	+	.	.	.	+	+	+	+	.	.	+	.	1	40
Juniperus communis	+	.	+	+	.	.	.	.	.	+	.	.	.	.	+	+	+	+	.	.	40
Hieracium murorum	.	+	.	.	.	+	.	+	.	.	.	+	.	+	+	.	.	.	1	.	35
Cerastium semidecandrum	.	+	+	.	.	+	+	.	+	.	.	+	+	.	.	.	.	.	.	.	35
Dactylorhiza maculata subsp. fuchsii	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	+	.	+	+	.	30
Ranunculus lanuginosus	.	.	.	.	.	+	.	+	+	+	.	.	+	+	.	.	.	.	.	.	30
Daphne mezereum	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	+	.	.	+	.	25
Cytisus scoparius	.	.	1	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	20
Hieracium piloselloides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	15
Platanthera chlorantha	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	+	.	.	+	15

Rare spcies: Campanula rotundifolia: rel. 119 (+), 126 (+); *Crepis leontodontoides*: rel. 118 (+), rel. 119 (+); *Galium verum*: rel. 132 (1), rel. 134 (+); *Leontodon hispidus*: rel. 118 (+), rel. 126 (+); *Picris hieracioides*: rel. 119 (+), rel. 124 (+); *Rumex acetosa*: rel. 118 (+), rel. 126 (+); *Anthoxanthum odoratum*: rel. 132 (2); *Cirsium morisianum*: rel. 122 (+); *Cruciata laevipes*: rel. 124 (+); *Cynosurus cristatus*: rel. 132 (3); *Dactylorhiza sambucina*: rel. 125 (+); *Euphrasia stricta*: rel. 121 (+); *Hypericum humifusum*: rel. 119 (+); *Lilium martagon*: rel. 131 (r); *Luzula nivea*: rel. 130 (+); *Narcissus poeticus*: rel. 129 (+); *Platanthera bifolia*: rel. 126 (+); *Ranunculus sardous*: rel. 127 (+); *Rubus idaeus*: rel. 131 (+); *Silene italica*: rel. 115 (+); *Stellaria graminea*: rel. 133 (1).