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Dry grasslands of central-western Po Plain (Italy): implications under Council Directive 92/43/EEC*

Silvia Assini[1,2], Ilaria Brugellis[1], Juri Nascimbene[3], Matteo Barcella[1], Alessia Gressani[1], Gabriele Gheza[3]

1 *Department of Earth and Environmental Sciences (Operative Unit Land Ecology), University of Pavia, Via Sant'Epifanio 14, 27100 Pavia, Italy*

2 *Botanical Garden, University of Pavia, Via Sant'Epifanio 14, 27100 Pavia, Italy*

3 *BIOME Lab, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum – University of Bologna, Via Irnerio 42, 40126 Bologna, Italy*

Corresponding author: Ilaria Brugellis (ilaria.brugellis01@universitadipavia.it)

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Abstract

This paper provides an overall look on the diversity of lowland dry grasslands of the western Po Plain, useful to support their conservation and management. Specific aims were: 1) to identify lowland dry grassland-associated plant communities at alliance level, which is useful for their classification under the Council Directive 92/43/EEC, 2) to assess their synecological and synchorological differences, 3) to define the equivalent Directive habitats and their management implications. Seven subareas were analysed: Lomellina, Ticino River, Sesia River, Po River (North), Orba Stream, Scrivia Stream, and Serio River. Floristic-vegetational relevés were carried out considering vascular plant, moss and lichen species. Cluster analysis were performed to syntaxonomically classify them, while statistical tests were performed to characterize them by means of biological life forms, chorotypes and Ellenberg indicator values. Eight plant communities were classified at alliance level and three plant communities were classified at class level. The equivalence with three Natura 2000 Habitats (H2330, H6110* and H6210) was found. Of the 60 studied sites, the 68% are located inside the Natura 2000 Network, while the remnant 31% are located outside. Possible management actions include: cutting of woody species, mowing, *sod-cutting*, transplants of typical herbaceous species, and *ex novo* restoration using harvested seeds from donor grasslands.

Keywords

Dry grasslands, lowlands, Italy, syntaxonomy, synecology, synchorology, Council Directive 92/43/EEC, Natura 2000 Network, management

Introduction

Grasslands are fundamental components of Earth's system, supporting a biodiverse array of plants, birds, insects and other animals, and providing important ecosystems services such as pasture forage, water regulation, freshwater supply, erosion control, pollination, and carbon sequestration (Buisson et al. 2022).

Dry grasslands are mainly characterized by oligotrophic soils, severe edaphic conditions, and, in many cases, extreme local climatic contexts (Scheidegger and Clerc 2002; Gheza et al. 2018). As the climate in most areas of the Palearctic is humid and warm enough to support forest growth, dry grasslands occur as potential large-scale vegetation only in the steppes of Eastern Europe and Central Asia (too dry for forests) and in the mountains above the tree line (growing season too short for forests) (Janišova et al. 2011). Small natural dry grassland stands occur where forests cannot grow due to edaphic factors, for example on saline soils, in coastal dunes, on very shallow soils surrounding rocky outcrops, on unstable soils and steep slopes (Ellenberg and Leuschner 2010; Klötzli et al. 2010).

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European dry grasslands are mostly of zoo-anthropogenic origin. Many dry grassland communities are semi-natural habitats that have developed over centuries of traditional land uses, such as mowing, grazing, seasonal and annual rotations of crop fields, and other disturbance regimes (Pott 1995; Ellenberg and Leuschner 2010; Janišova et al. 2011). The expansion of large-scale intensive agriculture on one hand, and abandonment on the other, have caused dramatic losses in quantity and quality for these habitats in recent decades, for example in the natural steppes of Eastern Europe and Central Asia, most of which have been converted to arable land (Janišova et al. 2011). While mesic and wet grasslands cover much larger areas in Europe, dry grasslands are less widespread, in spite of being the most diverse group, which is reflected in the much higher number of *syntaxa* (Rodwell et al. 2002) and by the fact that for areas smaller than 100 m^2, world records of plant species richness occur in nutrient-poor grasslands (Janišova et al. 2011). This diversity has been observed in several studies conducted in Eastern Europe, e.g., Romania, Czech Republic, and Estonia (Kull and Zobel 1991; Klimeš et al. 2001; Dengler 2005; Dengler et al. 2009).

The Po Plain is an emblematic example of a lowland area heavily impacted, being severely anthropized and one of Europe's most polluted areas (European Environmental Agency 2019). Dry grasslands are rare in this area, because of urbanization and agricultural exploitation that led to natural habitat loss, pollution and eutrophication (Assini 2008). Moreover, they are often extremely fragmented, and the few remnants are often confined to marginal, unproductive and unmanaged areas along rivers (Assini et al. 2013). Here, many of them are at the southern limit of their range (European Commission 2016; Preislerová et al. 2022), being separated from the European Continental Biogeographical Region by the Alps, confining with the Mediterranean Biogeographical Region.

This peculiar phytogeographical position allows the coexistence of plants with different distribution ranges: from typical central-european and eurasiatic species to subatlantic, submediterranean, orophytes and steppic species. Furthermore, together with dry *Calluna* heaths, dry grasslands are the only habitats of the Po Plain still hosting terricolous lichens (Gheza et al. 2020). Therefore, they host a unique biodiversity which needs to be conserved. In Europe, dry grasslands on both siliceous and calcareous substrates are listed as habitats of conservation concern under the Annex I of the "Habitats Directive" (Council Directive 92/43/EEC), being threatened by multiple impacts. About 60% of the Annex I habitats are clearly linked to one or more phytosociological syntaxa (European Environmental Agency 2014), mainly classes, orders and alliances. More rarely associations are described. Thus, a phytosociological study of the lowland dry grasslands is appropriate to define their conservation and management issues.

Previous studies of the lowland dry grasslands of the central-western Po Plain are localized, incomplete and fragmentary. Bracco et al. (1984) described *Sedo-Scleranthetea* Br.-Bl. 1955 and *Festuco-Brometea* Br.-Bl. ex Tx. ex Soò 1947 plant communities along the Po, Tanaro and Scrivia rivers. Assini (2002) described plant communities of *Koelerio-Corynephoretea canescentis* Klika in Klika et Novàk 1941 along the Po River in the central-western Po Plain (2002). Assini (2007) also described the association S*pergulo morisonii-Corynephoretum canescentis* Tx. (1928) 1955 on the inland sand dunes of Lomellina. Assini et al. (2013) described then Italian *Corynephorus canescens* (L.) P.Beauv. communities. Assini and Sartori (2004) described xeric herbaceous vegetation of *Thero-Airion* Tx. ex Oberd. 1957 and *Koelerio-Phleion phleoides* Korneck 1964 along the lower Ticino River. Lonati and Lonati (2007) described xerophilous grasslands dominated by *Festuca trachyphylla* (Hackel) Krajina of low Valsesia. Xero-thermophile pioneer grasslands of *Alysso alyssoidis-Sedion albi* Oberd. et T. Müller in T. Müller 1961, occurring along the Serio River, were described by Gariboldi (2010). Chamaephyte-dominated xero-thermophile grasslands of *Xerobromion* (Br.-Bl. et Moor 1938) Moravec in Holub et al. 1967 were described by the same author. Andreucci and Castelli (2002) described herbaceous vegetation of the Scrivia stream, with particularly focus on pioneer therophytic grasslands and their dynamic facies leading to the *Erodio-Brometum* (*Sedo-Scleranthetea*), dry grasslands with strong chamaephytic component on gravel deposits (*Helianthemo oelandici-Thymetum vulgaris*) forming mosaics with xerophylous vegetation (*Alysso-Sedion*), grasslands dominated by *Bromus erectus* (*Bromion erecti*).

With few exceptions, the above cited studies did not consider lichens and bryophytes, and only preliminary phytosociological studies devoted to lichen communities have been carried out in *Corynephorion* and *Thero-Airion* grasslands along the Ticino and Sesia rivers (Gheza et al. 2016, 2019). On a large scale, a comprehensive analysis of lowland dry grasslands considering vascular plants and cryptogams is not available. The general aim of this paper is therefore to provide an overall look on the diversity of lowland dry grasslands of the western Po Plain, useful to support their conservation and management. Specific aims include: 1) to identify lowland dry grassland-associated plant communities at alliance level, which is useful for their classification under the Council Directive 92/43/EEC, 2) to assess their synecological and synchorological differences, 3) to define the equivalent Directive habitats and their management implications.

Materials and methods

Study area

The study area is located in the central-western Po Plain, from east of Turin in Piedmont to the border between Lombardy and Veneto. It consists of 7 subareas, reported in Fig. 1: Lomellina, Ticino River, Sesia River, Po River (North), Orba Stream, Scrivia Stream, and Serio River. Inside them, we investigated 60 sites hosting dry grasslands. Geographical details of the study sites are shown in

Suppl. material 1. The average annual temperature in this area varies between 11 °C and 13.5 °C. Annual precipitation varies between 600 mm and 1200 mm (Gheza 2018). The altitude varies between 70 and 400 m.a.s.l. Soil pH ranges from very acidic and acidic, to sub-neutral and basic.

Sampling design

Sampling was carried out within circular plots of 3 m radius. At each study site, the number of plots was proportional to the area: 1 plot for areas between 100 and 1000 m^2; 2 plots between 1001 and 3000 m^2; 3 plots between 3001 and 5000 m^2; 5 plots between 5001 and 20000 m^2; and 7 plots for areas larger than 20000 m^2. Overall, 185 plots were sampled. In each study site, the plots were placed at regular intervals along a linear transect between the two farthest vertices of the area. The preliminary location of the plots was defined using QuantumGis Software (QGIS Geographic Information System: http://www.qgis.org/), while their location in field was found using a Garmin GPS.

Data collection

Floristic-vegetational relevés were carried out from April to June 2016. For each relevé, the percentage cover and average height of the five vegetation layers (tree, high shrub, low shrub, herb, moss-lichen) were annotated. Following a multi-taxon approach, we recorded the percentage cover of individual vascular plant, moss and lichen species.

We identified most of the species in the Laboratory of Flora, Vegetation and Ecosystem Services at the University of Pavia, where voucher specimens are stored. Several lichen specimens (identifiable only on the base of chemical analysis) were checked by thin-layer chromatography for secondary metabolites. An experienced bryologist supported the identification of critical bryophyte specimens. Species nomenclature follows Bartolucci et al. (2018) and Galasso et al. (2018) for vascular plants, Hodgetts et al. (2020) for bryophytes, and Nimis (2024) for lichens.

Data analysis

We performed a first cluster analysis using only vascular plant species occurring in at least 5% of the relevés. This resulted in a matrix of 185 relevés × 90 species. Species cover values were converted to abundance-dominance values according to Van der Maarel (1979).

We then performed further cluster analyses using Unweighted Pair Group Method with Arithmetic Mean (UPGMA) as the agglomerative criterion and Euclidean distance as the similarity measure. The cluster analyses results were tested by nonparametric One-Way ANOSIM

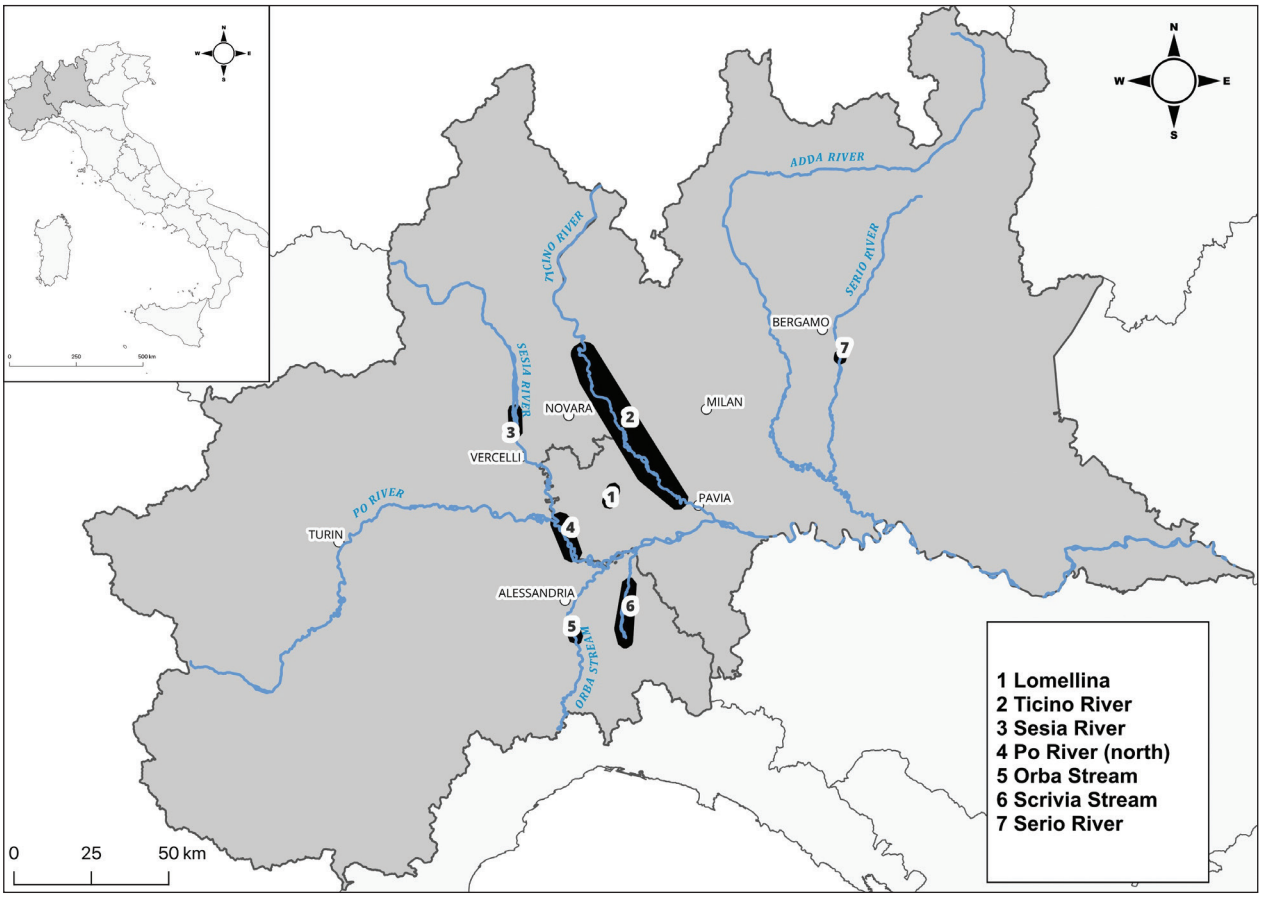

Figure 1. Study area reporting the seven considered subareas.

similarity analysis and nonparametric One-Way PERMANOVA analysis of variance.

The analyses were performed using the software PAST 4.09 (Hammer et al. 2001).

Syntaxonomical classification

As criteria for the syntaxonomical classification of the relevés, we considered the characteristic species of Alliances and Orders described by Oberdorfer (1978), and the characteristic species of Class described by EVC (Mucina et al. 2016). Only for the Alliance *Corynephorion canescentis* Klika 1931, we considered the characteristic and diagnostic species indicated by the Italian Vegetation Prodrome (Biondi et al. 2014; Blasi et al. 2014). In fact, Italian *Corynephorus canescens* plant communities are located at the southern limit of their European distribution and, therefore, the Italian Prodrome is more specific in characterizing them, if compared to works on a broader geographic scale. The syntaxonomical nomenclature follows Mucina et al. (2016).

In the synoptic table (Table 2), Roman numbers indicate the percentage frequency of species in each group of relevés (columns): I = frequency comprised between 0 and 20%, II = frequency comprised between 20 and 40%, III = frequency comprised between 40 and 60%, IV = frequency comprised between 60 and 80%, V = frequency comprised between 80 and 100%.

Synecological-synchorological characterization

We considered Ellenberg Indicator Values (EIVs) (Pignatti 2005; Domina et al. 2018), Raunkiær life forms (Raunkiær 1937) and chorological types, comparing them among the groups resulting after the cluster analysis. For groups containing up to five relevés, we kept all species. For groups containing more than five relevés, we kept only species with a frequency higher than one.

We elaborated EIVs transforming abundance-dominance values into weights according to Ellenberg (1974). We analysed the soil reaction, nutrient content and continentality, considering their values' distribution in each of the obtained clusters.

We grouped chorological types (as defined by Pignatti 1982) in the following ten categories:

1. Adventitious;
2. Circumboreal;
3. Endemic;
4. Cosmopolitan (including sub-cosmopolitan and thermo-cosmopolitan);
5. European (including Eurasian, Central-European, North-Central-European, European-Caucasian, Eurosiberian, European Orophytes);
6. South-European (including South-European-South-Siberian, South-European Orophytes, South and Central-European);
7. West-European-Mediterranean (including West-European - Subatlantic, West-Mediterranean montane, West Stenomediterranean, West and Central-European, Subatlantic, Euro-Mediterranean-Subatlantic, and West-Mediterranean);
8. Mediterranean (including Eurimediterranean, Stenomediterranean, North-Eurimediterranean and North-Mediterranean-Mountain);
9. Paleotemperate (including Subtropical);
10. Pontic-Turanian (including Euro-Mediterranean-Pontic and Stenomediterranean-Turanian).

We performed chorological spectra weighted on the central cover values for each cluster. Then the distributions of the central cover values of the clusters were compared between them only for the following chorological categories: Adventitious and Cosmopolitan (as indicators of environmental degradation), Circumboreal and Western-European-Mediterranean (as indicators of Western, Eurasian, and temperate-fresh influence), and Mediterranean, Paleotemperate, and Pontic-Turanian (as indicators of Mediterranean and temperate-warm influence).

We also performed Raunkiær life forms' spectra weighted on the central cover values for each cluster. Then the distributions of the central cover values of the clusters were compared between them for the following life forms: Chamaephytes, Hemicryptophytes, Terophytes, Phanerophytes and Nanophanerophytes.

Kruskal-Wallis and Mann-Whitney statistical tests were performed on the distribution of chosen EIVs, chorological types and Raunkiær life forms, in order to verify the existence of statistically significant differences between the clusters. The normality of the samples was preliminarily checked by the Shapiro-Wilk test. All statistical analyses were performed with the software PAST 4.09 (Hammer et al. 2001).

Results

Cluster analysis

The dendrogram resulted from the first cluster analysis performed on all the 185 relevés is reported in Fig. 2. Four distinct groups are observable: the SERIO group, the PO group, the ORBA-SCRIVIA group, and a huge group of 115 relevés including the Sesia, Ticino and Lomellina subareas. The ANOSIM and PERMANOVA tests both confirmed the statistical significance of these groups (*p values* < 0.05).

The dendrogram resulted from the second cluster analysis performed on the 115 relevés of the previously obtained Sesia-Ticino-Lomellina group is reported in Fig. 3. Four main groups are distinguishable: GR4TIC (including relevés from Ticino), GR1STL (including 85 relevés from Ticino, Lomellina and Sesia), GR2SES (including only relevés from Sesia), and GR3TIC (including relevés from Ticino).

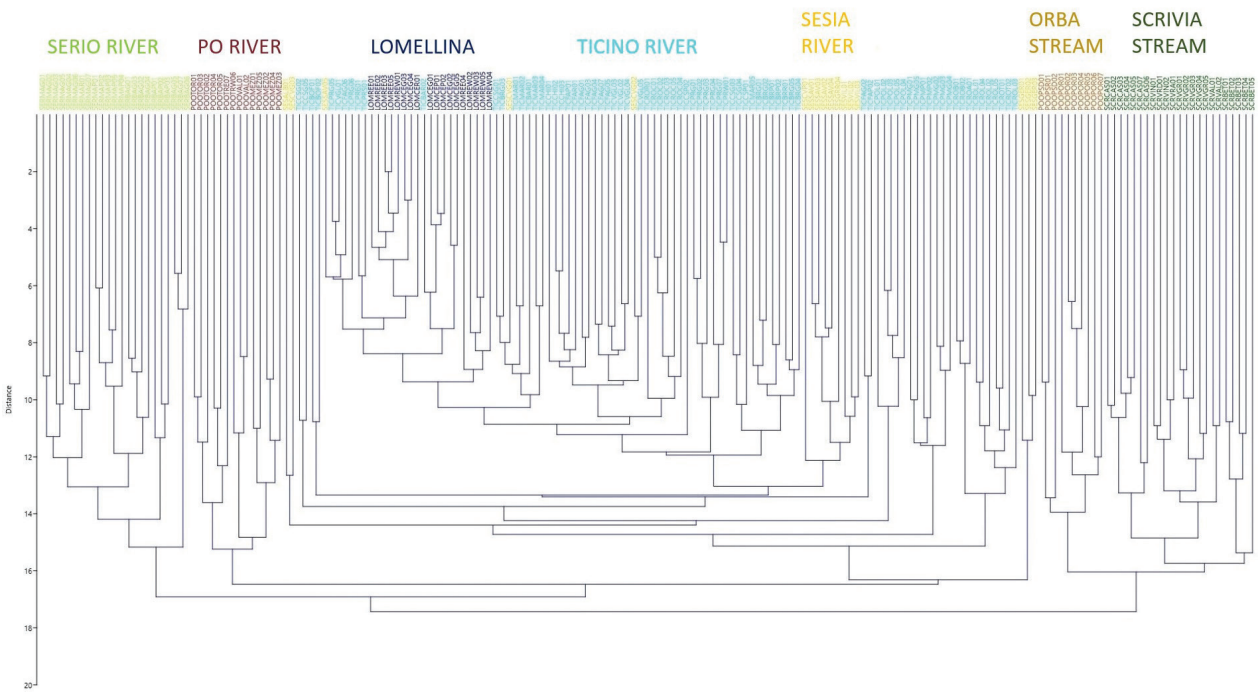

Figure 2. Dendrogam resulting from the first cluster analysis.

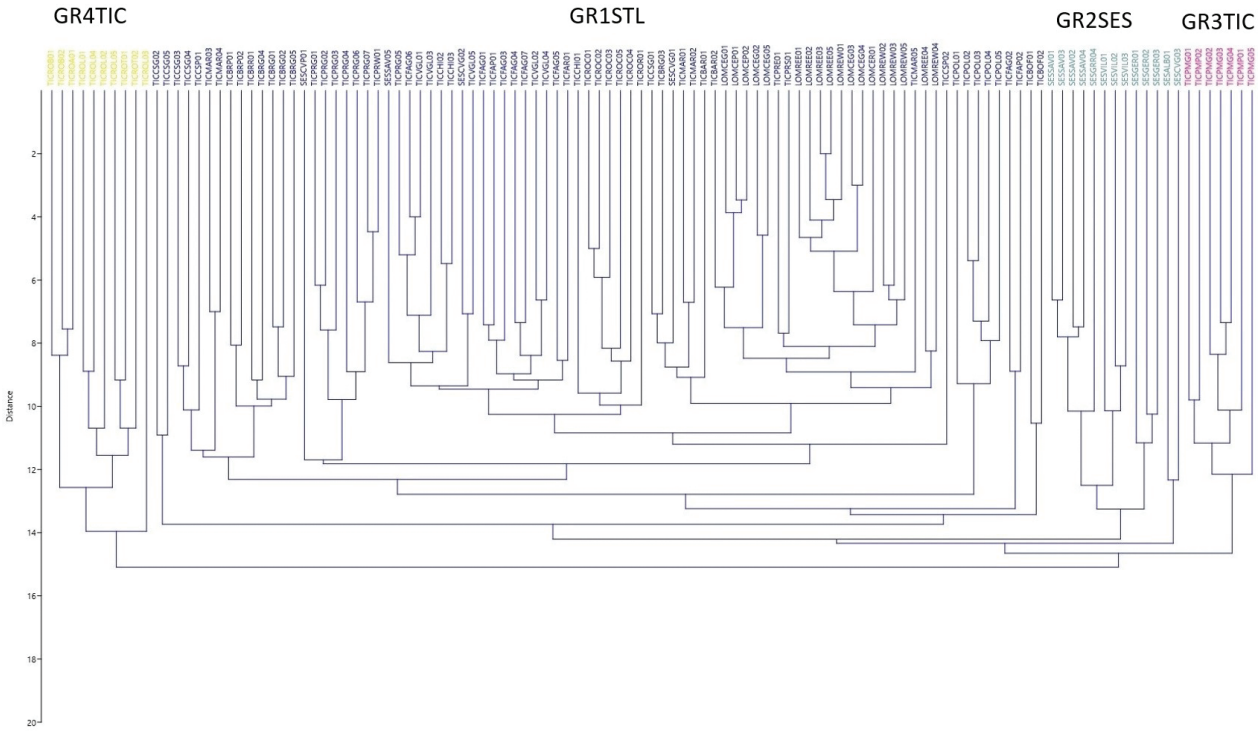

Figure 3. Dendrogam resulting from the second cluster analysis.

We then performed further cluster analysis separately on the groups of relevés resulted from the previous cluster analysis: GR1STL, GR2SES, GR3TIC, GR4TIC (derived from the second cluster analysis), SERIO, PO and ORBA-SCRIVIA (already well separated in the first cluster analysis).

We then obtained 7 final dendrograms (Suppl. materials 2–8) and 17 groups of relevés to be proceeded under the syntaxonomical and ecological analyses.

Syntaxonomical analysis

The 17 groups of relevés resulted from the previously described cluster analyses were classified, considering the characteristic species of classes, orders and alliances describing dry grassland communities. Results are shown in Table 1.

Cluster GR1STL_1 includes 5 relevés attributed to the alliance *Thero-Airion*, due to the presence of the following species: *Hypochaeris glabra* L., *Logfia minima* (Sm.)

Table 1. Description and syntaxonomical assignation of cluster groups.

Final Clusters	Description	Syntaxa
GR1STL_1	Pioneer grasslands of the Ticino River with *Festuca danthonii*.	Alliance *Thero-Airion* Tx. ex Orberd. 1957
GR1STL_2	Poor pioneer grasslands of the Ticino River, Sesia River and Lomellina inland dunes dominated by *Corynephorus canescens*	Alliance *Corynephorion canescentis* Klika 1931
GR1STL_3	Mixed pioneer grasslands of the Ticino River and Sesia River	Alliance *Thero-Airion* Tx. ex Orberd. 1957
GR2STL_4	Exotic-rich mixed grasslands of the Ticino River and Sesia River at different dynamic stages	Alliance *Thero-Airion* Tx. ex Orberd. 1957 and Alliance *Corynephorion canescentis* Klika 1931
GR2SES_5	Grasslands of the Sesia River with *Corynephorus canescens*	Alliance *Corynephorion canescentis* Klika 1931
GR2SES_6	Grasslands of the Sesia River with *Eragrostis curvula*	Alliance *Thero-Airion* Tx. ex Orberd. 1957
GR2SES_7	Mature and exotic-rich grasslands of the Sesia River	Alliance *Thero-Airion* Tx. ex Orberd. 1957
GR3TIC_8	Perennial grasslands of the Ticino River with *Artemisia campestris* and *Fumana procumbens*	Alliance *Koelerion-Phleion phleoidis* Korneck 1974.
GR4TIC_9	Pioneer grasslands of the Ticino River with *Festuca myuros*	Alliance *Thero-Airion* Tx. ex Orberd. 1957
GR4TIC_10	Degraded grasslands of the Ticino River	Syntaxonomically not classifiable
ORBA-SCRIVIA_11	Pioneer grasslands of the Orba Stream and Scrivia Stream with *Sedum sexangulare* and *Petrosedum rupestre*	Alliance *Alysso alyssoidis-Sedion* Orberd. et T. Muller in T. Muller 1961
ORBA-SCRIVIA_12	Mature grasslands of the Scrivia Stream with *Sedum sexangulare* and *Petrosedum rupestre*	Class *Sedo-Scleranthetea* Br.-Bl. 1955
SERIO_13	Pioneer grasslands of the Serio River with *Erodium cicutarium* and *Sedum sexangulare*	Alliance *Alysso alyssoidis-Sedion* Orberd. et T. Muller in T. Muller 1961
SERIO_14	Mature perennial grasslands of Serio River	Class *Festuco-Brometea* Br.-Bl. ex Tx. ex Soò 1947
SERIO_15	Mature grasslands of Serio River with *Erodium cicutarium* and *Sedum sexangulare*	Alliance *Alysso alyssoidis-Sedion* Orberd. et T. Muller in T. Muller 1961
PO_16	Grasslands of the Po River dominated by *Sedum sexangulare*, *Petrosedum rupestre* and *Trifolium campestre*	Class *Sedo-Scleranthetea* Br.-Bl. 1955
PO_17	Ruderal grasslands of the Po River	Class *Sedo-Scleranthetea* Br.-Bl. 1955

Dumort. (Alliance *Thero-Airion*, Order *Thero-Airetalia* Rivas Goday 1964), *Rumex acetosella* L., *Aira caryophyllea* L. and *Tuberaria guttata* (L.) Fourr. (Class *Sedo-Scleranthetea*). In the Italian Vegetation Prodrome (Biondi et al. 2014; Blasi et al. 2014), which follows a Mediterranean setting (Rivas-Martínez et al. 2002), the alliance *Thero-Airion* is included in the order *Tuberarietalia guttatae* Br.-Bl. in Br.-Bl., Molinier et Wagner 1940 *nom. mut. propos.* Rivas-Martínez, Diaz, Fernández-González, Izco, loidi, Lousa et Penas 2002 and in the class *Tuberarietea guttatae* (Br.-Bl., Roussine et Negre 1952) Rivas Goday et Rivas-Martínez 1963 *nom. mut. propos.* Rivas-Martínez, Diaz, Fernández-González, Izco, Loidi, Lousa et Penas 2002. However, considering the localization of our sites in the Continental Biogeographical Region, we used the EVC (Mucina et al. 2016) for the syntaxonomical nomenclature, which classifies the alliance *Thero-Airion* in *Thero-Airetalia* and *Sedo-Scleranthetea*.

Cluster GR1STL_2 includes 26 relevés attributed to the Alliance *Corynephorion canescentis* due to the presence of the following species: *Corynephorus canescens*, *Teesdalia nudicaulis* (L.) W.T.Aiton, *Logfia minima*, *Rumex acetosella* (Alliance *Corynephorion canescentis*, Order *Corynephoretalia canescentis* Klika 1934), *Aira caryophyllea*, *Echium vulgare* L., *Herniaria glabra* L., *Pilosella officinarum* Vaill. (Class *Koelerio-Corynephoretea canescentis*). Relevés TICCSP02, TICPRE01, TICPRS01, which appeared isolated and/or aggregated to the clusters at high levels of similarity in the cluster analyses, were also found to be poor in diagnostic species, and excluded from syntaxonomical classification.

Cluster GR1STL_3 includes 25 relevés attributed to the alliance *Thero-Airion*, due to the presence of the following species: *Hypochaeris glabra*, *Logfia minima*, *Teesdalia nudicaulis* (Alliance *Thero-Airion*, Order *Thero-Airetalia*), *Rumex acetosella*, *Aira caryophyllea*, *Poa bulbosa* L., *Tuberaria guttata* (Class *Sedo-Scleranthetea*).

Cluster GR1ST L_4 was manually elaborated to separate two groups of relevés. A first group of 12 relevés was attributed to the Alliance *Thero-Airion*, due to the presence of the following species: *Hypochaeris glabra*, *Logfia minima*, *Filago arvensis* L., *Teesdalia nudicaulis* (Alliance *Thero-Airion*, Order *Thero-Airetalia*), *Rumex acetosella*, *Aira caryophyllea*, *Poa bulbosa*, *Tuberaria guttata* (Class *Sedo-Scleranthetea*). A second group of 12 relevés was attributed to the alliance *Corynephorion canescentis* due to the presence of the following species: *Logfia minima*, *Corynephorus canescens*, *Rumex acetosella*, *Teesdalia nudicaulis*, *Jasione montana* (Alliance *Corynephorion canescentis*, Order *Corynephoretalia canescentis*), *Aira caryophyllea*, *Scleranthus perennis*, *Herniaria glabra*, *Festuca myuros* L., *Chondrilla juncea* L. (Class *Koelerio-Corynephoretea canescentis*). Relevés TICCSG02, TICCSG05, which appeared isolated and/or aggregated to the clusters at high levels of similarity in the cluster analyses, were also found to be poor in diagnostic species, and excluded from syntaxonomical classification.

Cluster GR2SES_5 includes 2 relevés attributed to the alliance *Corynephorion canescentis* due to the presence of the following species: *Jasione montana* L., *Rumex acetosella*, *Corynephorus canescens* (Alliance *Corynephorion canescentis*, Order *Corynephoretalia canescentis*),

Aira caryophyllea, *Festuca myuros*, *Hypochaeris radicata* L., *Artemisia campestris* L., *Sedum sexangulare* L. (Class *Koelerio-Corynephoretea canescentis*).

Cluster GR2SES_6 includes 5 relevés attributed to the Alliance *Thero-Airion*, due to the presence of the following species: *Logfia minima*, *Filago germanica* (L.) Huds. (Alliance *Thero-Airion*, Order *Thero-Airetalia*), *Aira caryophyllea*, *Rumex acetosella*, *Trifolium arvense* L., *Artemisia campestris* (Class *Sedo-Scleranthetea*).

Cluster GR2SES_7 includes 6 relevés attributed to the Alliance *Thero-Airion*, due to the presence of the following species: *Logfia minima*, *Hypochaeris glabra* (Alliance *Thero-Airion*, Order *Thero-Airetalia*), *Artemisia campestris*, *Aira caryophyllea*, *Rumex acetosella*, *Cerastium glutinosum* Fr., *Petrosedum rupestre* (L.) P.V.Heath (Class *Sedo-Scleranthetea*).

Cluster GR3TIC_8 includes 7 relevés attributed to the alliance *Koelerio-Phleion phleoides*, due to the presence of the following species: *Carex caryophyllea* Latourr., *Fumana procumbens* (Dunal) Gren. & Godr., *Festuca stricta* subsp. *trachyphilla* (Hack.) Patzke ex Pils (Alliance *Koelerio-Phleion phleoides*, Order *Festucetalia valesiacae*), *Bothriochloa ischaemum* (L.) Keng, *Teucrium chamaedrys* L., *Poa bulbosa*, *Stachys recta* L., *Potentilla pusilla* Host (Class *Festuco-Brometea*).

Cluster GR4TIC_9 includes 7 relevés attributed to the Alliance *Thero-Airion*, due to the presence of the following species: *Logfia minima*, *Hypochaeris glabra* (Alliance *Thero-Airion*, Order *Thero-Airetalia*), *Rumex acetosella*, *Poa bulbosa*, *Trifolium arvense*, *Bromus hordeaceus* L., *Scleranthus annuus* L., *Tuberaria guttata* (Class *Sedo-Scleranthetea*). All the relevés are characterized by the presence of *Festuca myuros* L.

Cluster GR4TIC_10 (relevés TICROB01, TICROB02, TICROA01) was not classified, as there were no diagnostic elements.

Cluster ORBA-SCRIVIA_11 includes 16 relevés attributed to the Alliance *Alysso alyssoidis-Sedion* Oberd. et T. Muller in T. Muller 1961, due to the presence of the following species: *Alyssum alyssoides* (L.) L., *Petrorhagia saxifraga* (L.) Link (alliance *Alysso alyssoidis-Sedion*, Order *Alysso-Sedetalia*), *Sabulina tenuifolia* (L.) Rchb., *Arabidopsis thaliana* (L.) Heynh. (Alliance *Alysso alyssoidis-Sedion*, Order *Alysso-Sedetalia*), *Petrosedum rupestre*, *Arenaria serpyllifolia* L., *Poa bulbosa* (Class *Sedo-Scleranthetea*).

Cluster ORBA-SCRIVIA_12 includes 17 relevés attributed to the Class *Sedo-Scleranthetea*, due to the presence of the following species: *Poa bulbosa*, *Erodium cicutarium* (L.) L'Hér., *Bromus hordeaceus*, *Artemisia campestris*, *Arenaria serpyllifolia*, *Petrosedum rupestre*.

Cluster SERIO_13 includes 6 relevés attributed to the Alliance *Alysso alyssoidis-Sedion*, due to the presence of the following species: *Petrorhagia saxifraga*, *Sabulina tenuifolia* (alliance *Alysso alyssoidis-Sedion*, Order *Alysso-Sedetalia*), *Echium vulgare*, *Medicago minima* (L.) L., *Sedum sexangulare*, *Erodium cicutarium*, *Thymus pulegioides* L., *Teucrium chamaedrys* (Class *Sedo-Scleranthetea*).

Cluster SERIO_14 includes 4 relevés attributed to the Class *Festuco-Brometea*, due to the presence of the following species: *Bothriochloa ischaemum*, *Eryngium campestre* L., *Teucrium chamaedrys*, *Carex caryophyllea*, *Helianthemum nummularium* (L.) Mill., *Thymus pulegioides*, *Potentilla pusilla*.

Cluster SERIO_15 includes 13 relevés attributed to the Alliance *Alysso alyssoidis-Sedion*, due to the presence of the following species: *Sabulina tenuifolia*, *Melica ciliata* L. (Alliance *Alysso alyssoidis-Sedion*, Order *Alysso-Sedetalia*), *Echium vulgare*, *Erodium cicutarium*, *Sedum acre* L., *Medicago minima*, *Arenaria serpyllifolia* (Class *Sedo-Scleranthetea*).

Cluster PO_16 includes 6 relevés attributed to the Class *Sedo-Scleranthetea*, due to the presence of the following species: *Trifolium arvense*, *Euphorbia cyparissias* L., *Petrorhagia saxifraga*, *Scleranthus annuus*, *Anisantha tectorum* (L.) Nevski.

Cluster PO_17 includes 8 relevés attributed to the Class *Sedo-Scleranthetea*, due to the presence of the following species: *Arenaria serpyllifolia*, *Petrorhagia saxifraga*, *Thymus pulegioides*, *Euphorbia cyparissias*, *Rumex acetosella*, *Cerastium glutinosum*, *Cerastium pumilum* Fr.

Synecological-synchorological characterization

The obtained and syntaxonomically elaborated clusters were compared among them, considering the EIVs, chorotypes and Raunkiær life forms distributions, to understand if clusters were significantly different in any of the above-mentioned factors. The significant differences among the groups for each factor are summarized in Suppl. material 9.

On the bases of the obtained results, we grouped the clusters of relevés attributed to the same syntaxonomical rank and not showing significant differences in EIVs, chorotypes and life forms. We then obtained 11 new groups reported in Table 2, which describe the analysed dry grasslands classified in the following *syntaxa*: *Thero-Airion*, *Alysso alyssoidis-Sedion*, *Sedo-Scleranthetea*, *Corynephorion canescentis*, *Koelerio-Phleion phleoidis* and *Festuco-Brometea*. Table 2 does not include sporadic species, which are listed, for each syntaxa, in Suppl. materials 10–15.

Thero-Airion

It is represented by three columns in Table 2:

- TA1 – containing clusters GR1STL_1, GR2SES_6, GR2SES_7 and GR4TIC_9, showing no significant differences for any of the synecological and synchorological factors.
- TA2 – containing cluster GR1STL_3, showing no significant differences from the above-mentioned cluster GR1STL_1, but is significantly different from the other 3 clusters of TA1 for at least one of the considered factors.

- TA3 – containing the first group manually separated from cluster GR1STL_4.

Alysso-Sedion

It is represented by two columns in Table 2:

- AS1 – clusters SERIO_13 and SERIO_15, showing no significant differences for any of the synecological and synchorological factors.
- AS2 – cluster ORBA-SCRIVIA_11, which is significantly different from the SERIO_15 cluster.

Sedo-Scleranthetea

It is represented by two columns in Table 2:

- SS1 - clusters PO_16 and PO_17, showing no significant differences for any synecological and synchorological factors.
- SS2 - cluster ORBA-SCRIVIA_12, which shows synecological and synchorological significant differences from clusters PO_16 and PO_17.

Corynephorion canescentis

It is represented by two columns in Table 2:

- CO1 – containing clusters G1STL2 and G2SES5, significantly different only for the Circumboreal chorological category.
- CO2 – containing the second group manually separated from cluster GR1STL_4.

Koelerio-Phleion pleoides

It is represented by one column in Table 2:

- KP – which includes cluster GR3TIC8 relevés.

Festuco-Brometea

It is represented by one column in Table 2:

- FB – which includes cluster SERIO_14 relevés.

Syntaxonomical scheme

Class *Koelerio-Corynephoretea canescentis* Klika in Klika et Novàk 1941
  Order *Corynephoretalia canescentis* Klika 1934
    Alliance *Corynephorion canescentis* Klika 1931
Class *Sedo-Scleranthetea* Br.-Bl. 1955
  Order *Thero-Airetalia* Rivas Goday 1964
    Alliance *Thero-Airion* Tx. ex Oberd. 1957
  Order *Alysso-Sedetalia* Moravec 1967
    Alliance *Alysso alyssoidis-Sedion* Oberd. et T. Muller in T. Muller 1961
Class *Festuco-Brometea* Br.-Bl. et Tx. ex Soò 1947
  Order *Festucetalia valesiacae* Soò 1947
    Alliance *Koelerio-Phleion phleoidis* Korneck 1974

Table 2. Synoptic table. Symbol legend: *1 also characteristic of *Corynephorion canescentis*; *2 also characteristic of *Koelerio-Corynephoretea canescentis*; **also characteristic of *Festuco-Brometea*; # Abundant and frequent in *Corynephorion canescentis*.

Vegetation unit	TA1	TA2	TA3	AS1	AS2	SS1	SS2	CO1	CO2	KP	FB
Nr. of relevés	23	25	12	19	16	14	17	28	12	7	4
Alliance *Thero-Airion* – Order *Thero-Airetalia*											
Logfia minima (Sm.) Dumort. *1	V	III	IV	.	.	II	.	III	IV	I	.
Hypochaeris glabra L.	III	IV	III	.	.	II	I	I	I	.	.
Teesdalia nudicaulis (L.) W.T.Aiton *1	.	III	II	.	.	.	.	III	IV	.	.
Filago arvensis L. *2	.	I	II	.	.	.	I	.	I	.	.
Filago germanica (L.) Huds.	I	.	.	.	I	.	I	.	.	.	.
Alliance *Alysso alyssoidis-Sedion* – Order *Alysso-Sedetalia*											
Petrorhagia saxifraga (L.) Link	I	.	.	II	III	V	I	.	.	V	II
Alyssum alyssoides (L.) L.	.	.	.	.	III	I	II	.	.	.	.
Sabulina tenuifolia (L.) Rchb.	.	.	.	V	I	.	.	.	.	.	.
Arabidopsis thaliana (L.) Heynh. *1	.	.	.	.	I	.	.	I	.	.	.
Melica ciliata L.	.	.	.	II	.	.	.	.	.	.	II
Class *Sedo-Scleranthetea*											
Poa bulbosa L.	II	III	III	.	IV	II	V	I	I	V	.
Aira caryophyllea L. *2	V	V	V	I	.	I	.	II	V	V	.
Erodium cicutarium (L.) L'Hér.	I	I	I	V	II	III	V	.	.	.	IV
Sedum sexangulare L. *2	I	.	.	V	II	III	III	I	.	I	II
Rumex acetosella L. *1	V	V	III	.	.	IV	.	II	V	V	.
Cerastium glutinosum Fr.	II	I	II	.	I	II	II	I	.	.	.
Veronica arvensis L.	I	I	I	.	I	I	II	I	.	.	.
Trifolium arvense L.	IV	I	I	.	I	IV	I	.	.	.	.

Vegetation unit	TA1	TA2	TA3	AS1	AS2	SS1	SS2	CO1	CO2	KP	FB
Nr. of relevés	23	25	12	19	16	14	17	28	12	7	4
Bromus hordeaceus L.	II	I	I	.	I	III	V	.	.	.	.
Artemisia campestris L. *2 ,**	III	.	.	.	II	II	V	I	.	III	.
Medicago minima (L.) L.	II	.	.	III	I	II	II	.	.	.	V
Arenaria serpyllifolia L.	I	.	.	II	V	IV	IV	.	.	I	.
Tuberaria guttata (L.) Fourr.	II	III	III	.	.	.	.	I	IV	.	.
Trifolium campestre Schreb.	I	.	.	I	I	II	II	.	.	.	.
Arabidopsis thaliana (L.) Heynh.	I	I	I	.	.	I	.	.	.	.	.
Scleranthus annuus L.	III	II	.	.	.	II	.	I	.	.	.
Potentilla argentea L.	I	.	II	.	I	I	.	.	.	.	.
Cerastium pumilum Curtis	I	.	.	.	.	II	I	I	.	.	.
Petrosedum rupestre (L.) P.V.Heath	I	.	.	.	V	II	IV	.	.	.	.
Viola arvensis Murray	II	.	.	.	I	.	I	I	.	.	.
Scleranthus perennis L. *2	I	I	.	.	.	.	.	.	II	.	.
Pilosella officinarum Vaill. *2	.	I	.	.	.	.	.	I	I	.	.
Cruciata pedemontana (Bellardi) Ehrend.	I	I	.	.	.	.	.	.	.	.	.
Cerastium semidecandrum L.	I	.	I	.	.	.	.	.	.	.	.
Petrorhagia prolifera (L.) P.W.Ball & Heywood	.	.	.	.	.	II	I	.	.	.	.
Cerastium brachypetalum Desp. ex Pers.	.	.	.	.	.	.	I	.	.	.	.
Myosotis ramosissima Rochel	I	.	.	.	.	.	.	.	.	.	.
Alyssum alyssoides (L.) L.	I	.	.	.	.	.	.	.	.	.	.
Sedum acre L.	.	.	.	III	.	.	.	.	.	.	.
Cryptogamic species of *Sedo-Scleranthetea*											
Ceratodon purpureus (Hedw.) Brid. *2	IV	IV	V	.	I	V	.	IV	IV	IV	.
Hypnum cupressiforme Hedw. *2 ,**	II	.	I	.	.	I	.	I	I	III	.
Racomitrium canescens (Hedw.) Brid. *2	II	I	.	.	.	III	.	I	.	II	.
Syntrichia ruralis (Hedw.) F.Weber & D.Mohr	.	.	.	.	II	II	II	.	.	.	.
Cladonia chlorophaea (Sommerf.) Spreng.	I	I	.	I	I	.	.	I	I	.	.
Cladonia foliacea (Huds.) Willd. #	II	IV	III	.	I	II	I	V	V	III	.
Cladonia furcata (Huds.) Schrad. #	I	II	I	.	.	.	.	IV	.	.	.
Cladonia rangiformis Hoffm. *2, **	V	IV	III	.	II	V	.	IV	IV	V	.
Cladonia symphycarpa (Flörke) Fr.	.	.	.	I	.	.	I	.	.	.	.
Polytrichum piliferum Hedw. *2	IV	IV	V	.	.	III	.	V	V	V	.
Psora decipiens (Hedw.) Hoffm. **	.	.	.	I	.	.	II	.	.	.	IV
Toninia sedifolia (Scop.) Timdal	.	.	.	.	II	.	III	.	.	.	.
Alliance *Corynephorion canescentis* – Order *Corynephoretalia canescentis*											
Corynephorus canescens (L.) P.Beauv.	I	.	.	.	.	.	.	V	V	II	.
Jasione montana L.	II	I	II	.	.	I	.	I	IV	.	.
Herniaria glabra L.	.	.	.	.	.	.	.	I	I	.	.
See other species with *1 in All. *Thero-Airion*, All. *Alysso-Sedion* and Class *Sedo Scleranthetea*											
Abundant and frequent in *Corynephorion*											
Chondrilla juncea L.	III	I	I	II	I	III	III	.	I	I	II
Cladonia pyxidata (L.) Hoffm.	I	II	I	.	.	.	.	II	II	IV	.
Hypochaeris radicata L.	I	II	III	.	.	.	.	I	II	I	.
Cladonia portentosa (Dufour) Coëm.	.	I	.	.	.	.	.	II	II	.	.
Cetraria aculeata (Schreb.) Fr.	.	.	.	.	.	.	.	I	.	.	.
See other species with # in Cryptogamic species of *Sedo-Scleranthetea* and Class *Festuco-Brometea*											
Class *Koelerio-Corynephoretea canescentis*											
Festuca myuros L.	III	I	III	I	II	IV	II	I	I	II	.
Echium vulgare L. **	II	.	.	V	III	III	.	I	I	II	III
Festuca lachenalii (C.C.Gmel.) Spenn.	I	III	I	.	.	II	.	I	.	IV	.
Armeria arenaria (Pers.) F.Dietr.	I	.	.	.	.	.	.	.	I	.	.
See other species with *2 in All. *Thero-Airion* and Class *Sedo-Scleranthetea*											
Cryptogamic species of *Koelerio-Corynephoretea*											
Campylopus introflexus (Hedw.) Brid.	.	III	II	.	.	.	.	I	III	III	.
Dicranum scoparium Hedw.	.	I	.	.	.	.	.	I	.	.	.
Cladonia fimbriata (L.) Fr.	.	.	.	.	I	.	.	.	I	.	.
Cladonia rei Schaer.	III	I	III	I	I	I	.	I	II	III	.
See other species with *2 in Cryptogamic species of *Sedo Scleranthetea*											

Vegetation unit	TA1	TA2	TA3	AS1	AS2	SS1	SS2	CO1	CO2	KP	FB
Nr. of relevés	23	25	12	19	16	14	17	28	12	7	4
Alliance *Koelerio-Phleion phleoidis* – Order *Festucetalia valesiacae*											
Teucrium chamaedrys L.	.	II	II	IV	IV	.	.	II	III	V	V
Fumana procumbens (Dunal) Gren. & Godr.	.	.	.	I	.	.	.	I	II	IV	II
Centaurium erythraea Rafn	.	.	.	.	.	.	.	.	I	I	.
Koeleria pyramidata (Lam.) P.Beauv.	II	.	.	.	.	.	.	.	.	I	.
Class *Festuco-Brometea*											
Hypericum perforatum L.	III	I	III	IV	I	II	I	II	III	IV	II
Bothriochloa ischaemum (L.) Keng	II	I	I	III	IV	.	IV	.	II	V	V
Potentilla pusilla Host	II	I	II	I	.	II	.	I	IV	V	IV
Helianthemum nummularium (L.) Mill.	I	.	I	I	I	.	II	I	I	.	IV
Carex caryophyllea Latourr.	.	II	II	III	.	.	III	.	II	III	V
Euphorbia cyparissias L.	II	.	.	.	III	V	II	I	I	III	.
Pilosella piloselloides (Vill.) Soják #	I	I	I	.	.	.	.	I	II	V	.
Poterium sanguisorba L.	I	.	.	II	V	II	V	.	.	III	.
Thymus pulegioides L.	II	.	I	IV	.	III	.	I	.	.	V
Stachys recta L.	I	I	.	.	II	.	I	.	.	V	.
Medicago lupulina L.	.	.	.	I	I	I	IV	.	.	.	III
Clinopodium nepeta (L.) Kuntze	.	.	.	II	II	I	.	.	.	.	II
Eryngium campestre L.	.	.	.	II	III	.	IV	.	.	.	V
Carduus nutans L.	.	.	.	II	.	.	.	.	.	I	IV
Bromopsis erecta (Huds.) Fourr.	.	.	.	.	I	.	I	.	.	.	III
Centaurea stoebe L.	I	.	.	II	.	.	.	.	.	.	III
Teucrium montanum L.	.	.	.	I	.	.	.	.	.	.	III
Achillea tomentosa L.	I	.	.	.	.	.	.	.	.	.	III
Cuscuta epithymum (L.) L.	.	.	.	I	.	.	.	.	.	.	II
Allium sphaerocephalon L.	.	.	.	.	.	.	.	.	.	.	III
Galium lucidum All.	.	.	.	.	.	.	.	.	.	IV	.
See other species with ** in Class *Sedo-Scleranthetea*											
Cryptogamic species of *Festuco-Brometea*											
See species with ** in Cryptogamic specie of *Sedo-Scleranthetea*											
Other vascular species											
Erigeron annuus (L.) Desf.	IV	II	V	II	II	V	II	III	III	V	IV
Erigeron canadensis L.	II	.	III	II	.	III	I	.	II	III	V
Centaurea deusta Ten.	I	.	I	.	III	IV	IV	I	I	V	.
Crataegus monogyna Jacq.	I	I	II	.	I	.	.	I	I	II	.
Euphorbia maculata L.	I	.	II	II	.	III	I	.	II	.	II
Anisantha sterilis (L.) Nevski	I	.	I	I	II	IV	II	I	.	.	.
Bromus squarrosus L.	II	.	.	II	I	IV	II	.	.	.	II
Robinia pseudoacacia L.	I	I	I	.	.	.	.	I	III	I	.
Geranium molle L.	I	I	.	I	I	I	III	.	.	.	.
Quercus robur L.	.	I	I	.	.	.	.	II	III	II	.
Oxalis stricta L.	III	I	I	.	.	II	.	.	I	.	.
Plantago lanceolata L.	.	.	I	II	.	I	II	.	.	.	IV
Valerianella locusta (L.) Laterr.	I	I	.	.	.	I	I	.	I	.	.
Oreoselinum nigrum Delarbre	I	I	I	.	.	.	.	I	.	II	.
Cynodon dactylon (L.) Pers.	I	.	I	.	.	I	I	I	.	.	.
Stachys recta L.	I	I	.	.	II	.	I	.	.	.	.
Myosotis arvensis (L.) Hill	.	.	.	.	.	II	I	I	I	.	.
Allium vineale L.	I	I	.	.	.	II	II	.	.	.	.
Rosa canina L.	.	I	I	I	.	.	.	.	II	.	.
Populus nigra L.	I	.	.	.	I	II	.	I	.	.	.
Galium divaricatum Lam.	I	.	II	I	.	.	.	.	.	.	IV
Geranium columbinum L.	II	.	.	.	I	.	I	I	.	.	.
Festuca danthonii Asch. & Graebn.	II	.	.	II	III	.	III	.	.	.	.
Reseda lutea L.	.	.	.	II	.	I	I	.	.	.	V
Thymus longicaulis C.Presl	I	.	.	.	III	.	III	.	I	.	.
Ailanthus altissima (Mill) Swingle	.	I	.	.	I	.	.	II	.	I	.

Vegetation unit	TA1	TA2	TA3	AS1	AS2	SS1	SS2	CO1	CO2	KP	FB
Nr. of relevés	23	25	12	19	16	14	17	28	12	7	4
Luzula campestris (L.) DC.	I	I	I	.	.	.	.	.	.	.	.
Festuca incurva (Gouan) Gutermann	.	.	II	.	III	II	.	.	.	.	.
Lathyrus sphaericus Retz.	.	.	.	.	I	I	I	.	.	.	.
Aphanes arvensis L.	I	II	III	.	.	.	.	.	.	.	.
Rubus caesius L.	.	I	I	.	.	.	.	I	.	.	.
Trifolium scabrum L.	I	I	.	.	.	.	III	.	.	.	.
Anisantha tectorum (L.) Nevski	.	.	.	.	I	III	I	.	.	.	.
Fraxinus ornus L.	.	I	.	.	.	.	.	I	.	I	.
Ulmus minor Mill.	.	.	I	I	I	.	.	.	.	.	.
Euphorbia helioscopia L.	.	.	.	.	I	.	II	.	.	.	.
Euphorbia falcata L.	.	.	.	.	II	.	III	.	.	.	.
Verbascum lychnitis L.	.	.	.	.	.	I	I	.	.	.	.
Pinus sylvestris L.	.	.	.	.	.	.	.	I	I	.	.
Oxalis dillenii Jacq.	.	.	.	II	.	.	.	.	.	.	II
Eragrostis curvula (Schrad.) Nees	II	I	.	.	.	.	.	.	.	.	.
Agrostis capillaris L.	.	I	II	.	.	.	.	.	.	.	.
Solidago gigantea Aiton	.	I	II	.	.	.	.	.	.	.	.
Cytisus scoparius (L.) Link	.	I	.	.	.	.	.	I	.	.	.
Galium parisiense L.	.	.	.	.	II	.	III	.	.	.	.
Ervilia hirsuta (L.) Opiz	I	.	.	.	.	I	.	.	.	.	.
Leontodon crispus Vill.	.	.	.	I	.	.	.	.	.	.	II
Silene nutans L.	.	.	.	.	.	.	.	.	II	I	.
Dactylis glomerata L.	I	I	.	.	.	.	.	.	.	.	.
Scabiosa columbaria L.	.	.	.	.	I	.	II	.	.	.	.
Sonchus asper (L.) Hill	.	.	.	.	I	.	I	.	.	.	.
Plantago sempervirens Crantz	I	.	.	.	.	IV	.	.	.	.	.
Crepis vesicaria L.	.	.	.	.	I	.	III	.	.	.	.
Crupina vulgaris Cass.	.	.	.	.	I	.	I	.	.	.	.
Poa pratensis L.	.	.	.	.	.	.	I	.	.	I	.
Polygonatum odoratum (Mill.) Druce	.	I	.	.	.	.	.	.	.	II	.
Populus × *canadensis* Moench	.	I	.	.	I	.	.	.	.	.	.
Linum usitatissimum L. subsp. *angustifolium* (Huds.) Thell.	.	.	.	.	I	.	I	.	.	.	.
Muscari comosum (L.) Mill.	.	.	.	.	I	.	III	.	.	.	.
Chrysopogon gryllus (L.) Trin.	.	.	I	.	.	.	.	.	I	.	.
Lysimachia arvensis (L.) U.Manns & Anderb.	.	.	.	I	I	.	.	.	.	.	.
Prunus serotina Ehrh.	.	.	.	.	.	.	.	I	I	.	.
Bombycilaena erecta (L.) Smoljan.	.	.	.	.	I	.	II	.	.	.	.
Ambrosia artemisiifolia L.	.	.	I	.	.	II	.	.	.	.	.
Satureja montana L.	.	.	.	.	II	.	I	.	.	.	.
Sedum rubens L.	.	.	.	.	III	II	.	.	.	.	.
Anchusa officinalis L.	.	.	.	.	.	IV	.	I	.	.	.
Artemisia alba Turra	.	.	.	.	II	.	III	.	.	.	.
Calluna vulgaris (L.) Hull	.	.	I	.	.	.	.	.	II	.	.
Other cryptogamic species											
Brachythecium albicans (Hedw.) Schimp.	.	I	.	II	.	I	.	.	.	.	.
Didymodon fallax (Hedwig) R.H.Zander	.	.	.	IV	V	.	V	.	.	.	III
Placidium squamulosum (Ach.) Breuss	.	.	.	.	III	.	III	.	.	.	.
Polytrichum formosum Hedw.	II	I	II	.	.	I	.	I	III	I	.
Rhynchostegium megapolitanum (Blandow ex F.Weber & D.Mohr) Schimp.	.	.	.	.	II	I	III	.	.	.	.
Riccia ciliifera Link	II	.	I	.	.	III	.	.	II	.	.
Tortella tortuosa (Hedw.) Limpr.	I	.	I	V	IV	II	IV	.	.	.	V
Cladonia cariosa (Ach.) Spreng.	II	.	I	.	.	.	.	.	.	.	.
Cladonia coccifera (L.) Willd.	.	II	.	.	.	.	.	I	IV	I	.
Cladonia peziziformis (With.) J.R.Laundon	II	.	.	.	.	I	.	.	.	.	.
Cladonia polycarpoides Nyl.	I	I	II	.	.	I	.	I	III	II	.
Cladonia squamosa (Scop.) Hoffm.	.	I	II	.	.	.	.	.	I	.	.
Cladonia strepsilis (Ach.) Grognot	.	.	.	.	.	.	.	I	I	.	.

Discussion

Thero-Airion (Table 2: TA1, TA2 and TA3)

We included in this syntaxon acidophilous dry grasslands from the Ticino and Sesia rivers, classified as *Thero-Airion*, for the presence of characteristic species of alliance and order (*Thero-Airetalia*), like *Logfia minima*, *Hypochaeris glabra* and *Teesdalia nudicaulis*. As class species (*Sedo-Scleranthetea*), both vascular species (e.g., *Rumex acetosella*, *Aira caryophyllea*, *Poa bulbosa*, *Tuberaria guttata*) and cryptogam species (e.g., *Ceratodon purpureus* (Hedw.) (Brid.), *Polytrichum piliferum* Hedw., *Cladonia rangiformis* Hoff., *Cladonia foliacea* (Huds.) Willd., *Cladonia furcata* (Huds.) Schrad.) are present.

Column TA1 includes 11 relevés from Sesia and 12 from Ticino. Column TA2 includes 23 Ticino relevés and 2 Sesia relevés. Column TA3 includes 11 relevés of the Ticino and 1 of the Sesia.

Column TA1 distinguishes from the others by the high frequencies of *Trifolium arvense* and *Artemisia campestris*, and the presence of *Medicago minima*, *Alyssum alyssoides*, *Arenaria serpyllifolia*, *Myosotis ramosissima* Rochel, *Petrosedum rupestre*, *Sedum sexangulare*, *Petrorhagia saxifraga*, *Trifolium campestre* Schreb. and *Cerastium pumilum* (all referable to the Class). Also *Filago germanica* (referable to the Alliance) is present only here.

In columns TA2 and TA3, *Teesdalia nudicaulis* and *Filago arvensis* (characteristic of the Alliance) are present.

Scleranthus annuus, *Cruciata pedemontana* (Bellardi) Ehrend., *Sclerantus perennis* L., the cryptogamic species *Racomitrium canescens* (Hedw.) Brid. and *Cladonia chlorophaea* (Sommerf.) Spreng. are represented both in TA1 and TA2 relevés. Column TA2 distinguishes by the presence of *Pilosella officinarum* Vaill., while *Potentilla argentea* L., *Cerastium semidecandrum* L. and *Hypnum cupressiforme* Hedw. are common to TA1 and TA3 relevés.

Other species common to the three columns include: *Festuca myuros*, *Chondrilla juncea*, *Festuca lachenalii* (C.C. Gmel.) Spenn., *Cladonia rei* Schaer., *Polytrichastrum formosum* (Hedw.) G.L.Smith and *Cladonia polycarpoides* Nyl.

In all three columns, species of *Festuco-Brometea* are present, such as *Hypericum perforatum* L., *Luzula campestris* (L.) DC., *Potentilla pusilla*, *Bothriochloa ischaemum*, *Pilosella piloselloides* (Vill.) Soják, but the species of this class are especially present in TA1 [*Euphorbia cyparissias*, *Centaurea stoebe* L., *Dianthus carthusianorum* L., *Echium vulgare*, *Koeleria pyramidata* (Lam.) P.Beauv., *Achillea tomentosa* L., *Armeria arenaria* (Pers.) F.Dietr., *Thymus longicaulis* C.Presl., *Poterium sanguisorba* L., *Silene otites* (L.) Wibel, *Helianthemum nummularium*, *Dianthus seguieri* Vill., *Plantago sempervirens* Crantz.], indicating a dynamic trend towards more mature grasslands.

In column TA2 and TA3 we notice the presence of many woody species (*Crataegus monogyna* Jacq., *Quercus robur* L., *Corylus avellana* L., *Fraxinus ornus* L., *Populus* × *canadensis* Moench, *Rosa canina* L., *Prunus spinosa* L., *Rhamnus cathartica* L. and *Ulmus minor* Mill.) indicating closure toward woodland and shrubs vegetation.

Non-native species [*Erigeron canadensis* L., *Erigeron annuus* (L.) Desf., *Oxalis stricta* L., *Robinia pseudoacacia* L., *Eragrostis curvula* (Schrad.) Nees, *Solidago gigantea* Aiton, *Euphorbia maculata* L., *Ailanthus altissima* (Mill.) Swingle, *Ambrosia artemisiifolia* L.] also occur.

Considering the life forms, TA1 relevés are significantly different from TA2 relevés for Chamaephytes, Terophytes and Hemicryptophytes.

Considering the chorotypes, TA1 relevés are significantly different from TA2 and TA3 relevés for Adventitious, but also for Circumboreal, Cosmopolite and Paleotemperate species.

Alysso alyssoidis-Sedion (Table 2: AS1 and AS2)

We included in this syntaxon basiphilous dry grasslands referred to alliance *Alysso alyssoidis-Sedion* (*Alysso-Sedetalia*) due to the presence of *Sabulina tenuifolia*, and *Petrorhagia saxifraga*. Class species (*Sedo-Scleranthetea*) such as *Erodium cicutarium*, *Arenaria serpyllifolia*, *Sedum sexangulare*, *Medicago minima* are also present in both columns.

Column AS1 includes 19 relevés from Serio. Column AS2 includes 6 relevés from Scrivia and 10 from Orba. Column AS1 distinguishes by the presence of *Melica ciliata* L., *Sedum acre*, *Aira caryophyllea*, *Psora decipiens*, *Cladonia symphycarpa*. Column AS2 distinguishes by the presence of *Alyssum alyssoides* and *Arabidopsis thaliana* (alliance-order species), being also the richest in class species as *Poa bulbosa*, *Potentilla argentea*, *Veronica arvensis*, *Artemisia campestris*, *Bromus hordeaceus*, *Cerastium glutinosum*, *Filago germanica*, *Viola arvensis*, *Petrosedum rupestre*, *Trifolium arvense*, *Toninia sedifolia*, *Ceratodon purpureus*, *Syntrichia ruralis* (Hedw.) F.Weber & D.Mohr and *Cladonia rangiformis*.

Both the columns show a dynamic trend toward perennial grasslands, for the presence of *Festuco-Brometea* species, such as *Echium vulgare*, *Teucrium chamaedrys*, *Hypericum perforatum*, *Poterium sanguisorba*, *Bothriochloa ischaemum*, *Eryngium campestre*, *Clinopodium nepeta*, *Helianthemum nummularium*, *Medicago lupulina*.

Teucrium montanum L., *Koeleria macrantha* (Ledeb.) Schult., *Cuscuta epithymum* (L.) L., *Ajuga chamaepitys* (L.) Schreb., *Potentilla pusilla*, *Fumana procumbens*, *Centaurea stoebe*, *Carduus nutans* L., *Carex caryophyllea*, *Thymus pulegioides* are present only in AS1, while *Thymus longicaulis*, *Satureja montana*, *Artemisia alba*, *Bromopsis erecta*, *Ononis natrix* L., *Globularia bisnagarica* L., *Hippocrepis comosa* L., *Scabiosa columbaria* are present only in AS2 relevés.

Adventitious species (*Erigeron canadensis*, *Euphorbia maculata*, *Oxalis dillenii* Jacq., *Erigeron annuus*) are more frequent in AS1 relevés, while woody species (*Ulmus minor*, *Crataegus monogyna*, *Populus nigra*, *Populus* × *canadensis*) are more frequent in AS2 relevés.

Considering the ecological factors, AS1 relevés are significantly different from AS2 relevés for soil reaction and nutrient content.

Considering the chorotypes, AS1 relevés are significantly different from AS2 relevés for Western-European-Mediterranean species (*Petrosedum rupestre*, *Sedum rubens* L., *Crepis vesicaria* L., *Satureja montana*), which are more abundant in AS2 relevés.

Sedo-Scleranthetea (Table 2: SS1 and SS2)

We included in this syntaxon dry grasslands from Po and Scrivia rivers, occurring on basic substrates. They are referable to the class *Sedo-Scleranthetea*, for the presence of *Petrorhagia saxifraga*, *Arenaria serpyllifolia*, *Erodium cicutarium*, *Sedum sexangulare*, *Poa bulbosa*, *Petrosedum rupestre*, *Artemisia campestris*, *Cerastium glutinosum*, *Cerastium pumilum*, *Alyssum alyssoides*, *Medicago minima*, *Petrosedum rupestre*, *Sedum sexangulare*, *Trifolium arvense*, *Trifolium campestre*, *Bromus hordeaceus*, *Hypochaeris glabra*, *Veronica arvensis* and *Syntrichia ruralis*.

Column SS1 includes 14 relevés coming from Po. Column SS2 includes 17 relevés coming from Scrivia.

SS1 distinguishes by the presence of *Rumex acetosella*, *Scleranthus annuus*, *Arabidopsis thaliana*, *Potentilla argentea*, *Aira caryophyllea*, *Ceratodon purpureus*, *Polytrichum piliferum*, *Racomitrium canescens*, *Hypnum cupressiforme*, *Cladonia rangiformis*, and *Cladonia foliacea*. Column SS2 is the poorest in *Sedo-Scleranthetea* species and distinguishes by the presence of *Viola arvensis*, *Filago germanica*, *Cerastium brachypetalum* Desp. ex Pers., *Cladonia symphycarpa* (Flörke) Fr., *Psora decipiens* (Hedw.) Hoffm. and *Toninia sedifolia* (Scop.) Timdal.

The array of *Festuco-Brometea* species is abundant: *Poterium sanguisorba*, *Medicago lupulina* L., *Allium vineale* L., *Hypericum perforatum*, *Verbascum lychnitis* L. are present in both columns; *Echium vulgare*, *Thymus pulegioides*, *Stachys recta*, *Salvia pratensis* L., *Erysimum rhaeticum* (Schleich. ex Hornem.) DC., *Clinopodium nepeta* (L.) Kuntze, *Potentilla pusilla*, *Plantago sempervirens* are present only in SS1; *Bothriochloa ischaemum*, *Eryngium campestre*, *Thymus longicaulis*, *Carex caryophyllea*, *Artemisia alba* Turra, *Heliantemum nummularium* (L.) Mill, *Scabiosa columbaria* L., *Satureja montana* L., *Crupina vulgaris* Cass., and *Bromopsis erecta* (Huds.) Fourr. occur only in SS2 relevés.

SS1 relevés are the richest in alien species (*Ambrosia artemisiifolia*, *Sorghum halepense* (L.) Pers., *Erigeron annuus*, *Erigeron canadensis*, *Oxalis stricta*, *Euphorbia maculata*).

Considering the ecological factors, SS1 relevès are significantly different from SS2 relevés for soil reaction and nutrient content.

Considering the chorotypes, SS1 relevés are significantly different from SS2 relevés for Adventitious species.

Corynephorion canescentis (Table 2: CO1 and CO2)

We included in this syntaxon *Corynephorus* grasslands from Ticino, Sesia, and Lomellina, referred to *Corynephorion canescentis* and *Corynephoretalia canescentis* for the presence of both vascular species (as *Corynephorus canescens*, *Logfia minima*, *Teesdalia nudicaulis*) and lichens [as *Cladonia foliacea*, *Cladonia pyxidata* (L.) Hoffm., and *Cladonia portentosa* (Dufour) Coëm]. Many cryptogamic class species (*Koelerio-Corynephoretea canescentis*) also occur (as *Polytrichum piliferum*, *Ceratodon purpureus*, *Hypnum cupressiforme*, *Cladonia rangiformis* and *Cladonia rei*).

Column CO1 includes 7 relevés from Ticino, 3 from Sesia and 18 from Lomellina. Column CO2 includes 12 relevés from Ticino. Column CO1 distinguishes from the other by the presence of *Arabidopsis thaliana*, *Artemisia campestris*, *Festuca lachenalii*, *Sedum sexangulare*, *Cladonia furcata*, *Cetraria aculeata* (Schreb.) Fr., *Dicranum scoparium* Hedw., and *Racomitrium canescens*. Column CO2 distinguishes by the presence of *Filago arvensis*, *Scleranthus perennis*, *Armeria arenaria*, *Chondrilla juncea* L., and *Cladonia fimbriata* (L.) Fr.

Festuco-Brometea species (*Hypericum perforatum*, *Teucrium chamaedrys*, *Potentilla pusilla*, *Fumana procumbens*, *Euphorbia cyparissias*, *Helianthemum nummularium*) and *Sedo-Scleranthetea* species (*Tuberaria guttata*, *Poa bulbosa*, *Hypochaeris glabra*) are present in both columns.

Cerastium glutinosum, *Viola arvensis* Murray, *Cerastium pumilum*, *Scleranthus annuus* and *Veronica arvensis* L. (*Sedo-Scleranthetea*) are present only in CO1. *Centaurium erythraea* Rafn, *Thymus longicaulis*, *Chrysopogon gryllus* (L.) Trin., *Carex caryophyllea* and *Bothriochloa ischaemum* (*Festuco-Brometea*) are present only in CO2 relevés.

As adventitious species, *Erigeron annuus*, *Robinia pseudoacacia* and *Prunus serotina* Ehrh. are present in both columns; *Ailanthus altissima* and *Amorpha fruticosa* L. are present only in CO1 relevés; *Oxalis stricta* and *Erigeron canadensis* are present only in CO2 relevés.

Woody species also occur (*Prunus padus* L., *Rosa canina*, *Quercus robur*, *Crataegus monogyna*, *Pinus sylvestris* L., *Fraxinus ornus*, *Populus nigra* L.).

Festuco-Brometea and woody species indicate a trend towards more mature dynamic stages.

Considering the life forms, CO1 relevés are significantly different from CO2 relevés for Hemicriptophytes and Terophytes.

Considering the chorotypes, CO1 relevés are significantly different from CO2 relevés for Circumboreal, Cosmopolite, Mediterranean and Paleotemperate species.

Koelerio-Phleion phleoides (Table 2: KP)

We included in this syntaxon perennial grasslands from Ticino referable to the Alliance *Koelerio-Phleion* (*Festucetalia valesiacae*, *Festuco-Brometea*) for the presence of species such: *Teucrium chamaedrys*, *Fumana procumbens*, *Bothriochloa ischaemum*, *Stachys recta*, *Pilosella piloselloides*, *Hypericum perforatum*, *Potentilla pusilla*,

Galium lucidum All., *Artemisia campestris*, *Cladonia rangiformis*, *Hypnum cupressiforme*.

Some of the abundant other species are referable to the Class *Sedo-Scleranthetea* (*Rumex acetosella*, *Aira caryophyllea*, *Poa bulbosa*, *Petrorhagia saxifraga*).

Festuco-Brometea (Table 2: FB)

We included in this syntaxon perennial basiphilous dry grasslands from Serio, referable to *Festuco-Brometea*, for the presence of species such as *Carex caryophyllea*, *Teucrium chamaedrys*, *Heliantemum nummularium*, *Bothriochloa ischaemum*, *Eryngium campestre*, *Thymus pulegioides*, *Potentilla pusilla* and *Psora decipiens*.

Such grasslands seem to show an affinity for the alliance *Bromion erecti* Koch 1926 (order *Brachypodietalia pinnati* Korneck 1974 *nom. conserv. propos.*), due to the presence of *Carex caryophyllea*, *Teucrium chamaedrys*, *Helianthemum nummularium*, *Blackstonia perfoliata* (L.) Huds., *Allium sphaerocephalum* L., *Centaurea stoebe*, *Medicago lupulina*, *Teucrium montanum*, *Bromopsis erecta*, *Fumana procumbens*.

Considering the other species, *Medicago minima*, *Reseda lutea* L., *Plantago lanceolata* L., *Erodium cicutarium*, *Galium divaricatum* Lam. and *Tortella tortuosa* (Hedw.) Limpr. are frequent. Some adventitious species (*Erigeron canadensis*, *Erigeron annuus*, *Euphorbia maculata*, *Oxalis dillenii*) are also present.

Equivalences among syntaxa and habitats

We used the syntaxonomical classification as a base to define the equivalence among syntaxa and Natura 2000 Habitats (under the Council Directive 92/43/EEC). Moreover, we also used the EUNIS 2021 classification (Chytrý et al. 2020; EEA 2021) to support such equivalence.

We considered pioneer acidophilous dry grasslands of *Thero-Airion* as Habitat 6210. Both the Italian Interpretation Manual (Biondi et al. 2009, 2012) and the Interpretation Manual of EU Habitats - EUR 28 (European Commission 2013) describe H6210 as *Festuco-Brometalia erecti*. Anyway, this order does not exist because in the syntaxonomical literature we only find *Festucetalia* and *Brometalia* (*Brachypodietalia*) orders. Therefore, we assumed H6210 to be described by the class *Festuco-Brometea*. Our inclusion of *Thero-Airion* (*Sedo-Scleranthetea*) in the H6210 is due to the evident presence of *Festuco-Brometea* species, which indicate its dynamic trend towards perennial grasslands. In fact, pioneer vegetation of *Thero-Airion* often coexists in a mosaic with more mature vegetation of *Festuco-Brometea* (related to the order *Festucetalia valesiacae* and/or alliance *Koelerio-Phleion phleoides*), differentiated by seasonality: in springtime we mostly observe annual species, while in summertime we mostly observe perennial species (Assini and Sartori 2004). Furthermore, to support our interpretation, we also considered the EU Interpretation Manual - EUR 28 (European Commission 2013), which states that H6210 grasslands are often associated with dry pioneer *Sedum* meadows (*Sedo-Scleranthetea*).

We, particularly, considered pioneer grasslands of *Thero-Airion* as subtype 34.34 - Central European calcaro-siliceous grasslands (*Koelerio-Phleion phleoidis*). *Thero-Airion* pioneer grasslands cannot be considered Habitat 6220* (Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*), as stated by the Italian Vegetation Prodrome (Biondi et al. 2014; Blasi et al. 2014). This is due to our inclusion in *Thero-Airetalia* and *Sedo-Scleranthetea*, and not in *Thero-Brachypodietalia* and *Thero-Brachypodietea* as indicated in the Interpretation Manual of EU Habitats - EUR 28 (European Commission 2013), which describes the H6220* as Meso- and thermo-Mediterranean xerophile, mostly open, short-grass annual grasslands rich in therophytes, and therophyte communities of oligotrophic soils on base-rich, often calcareous substrates.

If we consider the EUNIS 2021 classification, the studied *Thero-Airion* communities are floristically very specific (due to their phytogeographical position), being a mix between R1Q and R1R. They cannot be considered as R1Q because of the absence of *Corynephorus canescens* and *Spergula morisonii*, a lower number of atlantic species, and a higher abundance in cryptogamic crusts and *Teesdalia nudicaulis*. Furthermore, they cannot be considered as R1R because of the very low number of mediterranean species. It is important to stress that *Thero-Airion* communities form a very intimate mosaic with *Festuco-Brometea* (*Koelerion-Phleion*) grasslands, characterized by very diverse small patches, which are expression of the different substrate conditions. Little variations in organic contents and texture cause slight floristic variations, and therefore small patches of *Festuco-Brometea* intertwined with small patches of *Thero-Airion*.

The proposition of a new subtype seems not adequate because, as stated by Bonari et al. (2023), a mosaic is often difficult to manage and conserve. Therefore, we prefer consider a unique habitat, giving indications to manage it according to a dynamic approach, preserving both pioneer aspects (*Thero-Airion*) and mature aspects (*Festuco-Brometea*) by means of different types of actions.

Corynephorus grasslands, referred to the Alliance *Corynephorion canescentis*, are considered Habitat 2330 "Inland dunes with open *Corynephorus* and *Agrostis* grasslands". In fact, we can observe all the plants described by the Italian Manual (Biondi et al. 2009, 2012).

Acidic dry grasslands referable to *Koelerio-Phleion* are considered Habitat 6210 (subtype 34.34 - Central European calcaro-siliceous grasslands). In fact, this Alliance is explicitly mentioned in the description of the habitat, in the Italian Manual (Biondi et al. 2009, 2012) and EU Manual - EUR 28 (European Commission 2013).

Pioneer basiphilous dry grasslands referred to the Alliance *Alysso-Sedion* are considered priority Habitat 6110* "Rupicolous calcareous or basophilic grasslands of the

Alysso-Sedion albi", according to the interpretation of the Italian and EU Manuals.

Dry grasslands of *Sedo-Scleranthetea* could be considered Habitat 6210, for the same reasons explained about the Alliance *Thero-Airion*. Anyway, they are in a worst conservation status due to the presence of alien species, caused by the human impact.

Basiphilous dry grasslands referred to the Class *Festuco-Brometea* are considered Habitat 6210, according to the Italian and EU Manuals.

Conclusions

This work allowed to provide an overall look on the diversity of lowland dry grasslands of the western Po plain, with eight plant communities classified at alliance level and three plant communities classified at class level. Anyway, for all the 11 plant communities the equivalence with three Natura 2000 Habitats (under the Council Directive) was found, which are: H2330, H6110* and H6210.

It is clear that in the studied sites such habitats can host different plant communities, each of them with its floristic identity for vascular plants and cryptogamic species, confirming the importance of these habitats for rare terricolous lichens in the Po Valley (Gheza et al. 2018, 2019).

We found two different plant communities both for H2330 and H6110*, and five plant communities for H6210. Two plant communities were classified as *Sedo-Scleranthetea* and their equivalence with Directive habitats seem to be weak.

Previous phytosociological studies have already described different vascular plant and lichen associations in the context of *Corynephorion canescentis* (Assini 2007; Assini et al. 2013; Gheza et al. 2016), *Koelerio-Phleion* (Assini and Sartori 2004), and *Thero-Airion* (Assini and Sartori 2004; Gheza et al. 2019) highlighting the great vegetation diversity associable to continental and lowland dry grassland habitats. However, a more accurated analyses of our relevés could reveal other associations.

Habitat 6210 is particularly rich because it includes plant communities occurring on both calcareous and siliceous substrates. In the regions Lombardy and Piedmont (where our study sites are located), the H6210 of siliceous substrates is rarer. According our approximative estimation, it represents only 3% and 7% of the total surface occupied by H6210 (inside Natura 2000 Network), respectively in Lombardy and Piedmont.

As previously described, in many cases, the observed plant communities show a dynamic trend towards mature stages and the occurrence of non-native species. Furthermore, the nutrient soil content can affect the floristic composition. Therefore, as stated by Janišova et al. (2011), also in our study sites, the expansion of highly competitive species (both native and non-native) is a threat, often enhanced by increased atmospheric nitrogen deposition, which changes the proportion of available nutrients in soils and promotes the dominance of tall species and competitive grasses, especially in the absence of management.

Thus, these communities would need proper management and restoration activities to maintain and enhance their diversity and richness.

Particularly interesting is the case of basiphilous dry grasslands of the Scrivia River. Difficulties encountered in their syntaxonomical classification also affect the recognition of the equivalent Directive habitat. Due to a prolonged absence of management, such grasslands evolved towards mature stages characterized by an almost total lack of *Alysso-Sedion* species and, thus, classified only at class level (*Sedo-Scleranthetea*). Therefore, H6210 may be the equivalent Directive habitat. However, a restorative management could result in a reaffirmation of the above species, particularly where expressions of good preserved Habitat 6110* still occur in neighboring areas. In this case, dry grasslands of Scrivia could be considered as degraded H6110*, giving a greater naturalistic value to the host area, since it is a priority habitat.

According to the IV Report (2013–2018), ex-art.17 (Habitat Directive) (Ercole et al. 2021), the conservation status of the analysed habitats in the Italian Continental Biogeografical Region is bad with worsening trend for H2330 and H6210, while it is inadequate with improving trend for H6110*.

Possible management actions include: cutting of woody species (both native and non-native), with the mainteinance of the big trees of native oaks [*Quercus robur* L. and *Q. petraea* (Matt.) Liebl.], mowing, *sod-cutting* (Van Andel and Aronson 2012), transplants of typical herbaceous species produced in specialized nurseries (Blakesley and Buckley 2016), and *ex novo* restoration using harvested seeds from donor grasslands (Scotton 2016). They already have been realized during the on going project LIFE18 NAT/IT/000803 Drylands.

Anyway, a possible obstacle to the management and ecological restoration of the habitats here considered is represented by their location in relation to the Natura 2000 sites, established under the Habitats Directive and the Birds Directive (Council Directive 2009/147/EC). Natura 2000 Network (NN2000) is the more important network of areas protected at European level, which provides fundings and opportunities to sustain biodiversity protection inside them. Moreover, site-specific conservation measures are developed for their management.

Considering our 60 study sites, 68% of them are located inside NN2000 (Fig. 4), while the remnant 31% are located outside, and, particularly, 3% are located at 500 m from NN2000, 12% are located at 1–1.5 km from NN2000, 17% are located at more than 1.5 km from NN2000.

An effective biodiversity conservation action associated with the habitats analysed in the present paper should also be able to operate in sites outside the NN2000, which could host plant communities different from those occurring in Natura 2000 sites.

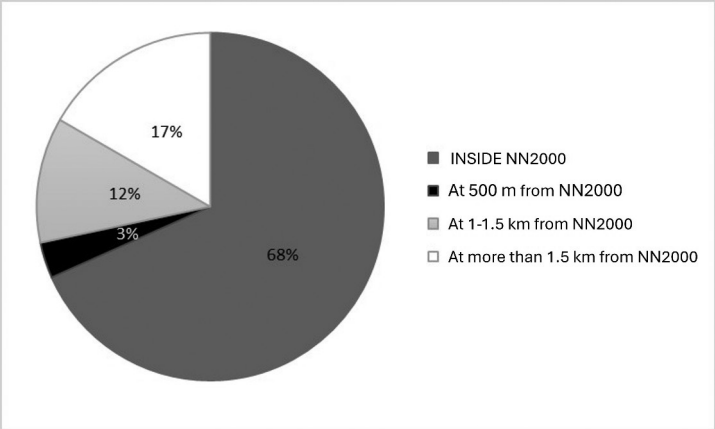

Figure 4. Localization of the study sites compared to NN2000 (Natura 2000 Network).

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Supplementary material 1

Geographical details of the study sites

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xls

Link: https://doi.org/10.3897/pls2024612/01.suppl1

Supplementary material 2

Dendrogram resulting from the cluster analysis of group GR1STL

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

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Supplementary material 3

Dendrogram resulting from the cluster analysis of group GR2SES

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

Link: https://doi.org/10.3897/pls2024612/01.suppl3

Supplementary material 4

Dendrogram resulting from the cluster analysis of group GR3TIC

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

Link: https://doi.org/10.3897/pls2024612/01.suppl4

Supplementary material 5

Dendrogram resulting from the cluster analysis of group GR4TIC

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

Link: https://doi.org/10.3897/pls2024612/01.suppl5

Supplementary material 6

Dendrogram resulting from the cluster analysis of group ORBA-SCRIVIA

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

Link: https://doi.org/10.3897/pls2024612/01.suppl6

Supplementary material 7

Dendrogram resulting from the cluster analysis of group SERIO

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

Link: https://doi.org/10.3897/pls2024612/01.suppl7

Supplementary material 8

Dendrogram resulting from the cluster analysis of group PO

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: jpg

Link: https://doi.org/10.3897/pls2024612/01.suppl8

Supplementary material 9

Significant differences among the 17 groups of relevés

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl9

Supplementary material 10

Thero-Airion table

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl10

Supplementary material 11

Alysso-Sedion table

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl11

Supplementary material 12

Sedo-Scleranthetea table

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl12

Supplementary material 13

Corynephorion table

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl13

Supplementary material 14

Koelerio-Phleion table

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl14

Supplementary material 15

Festuco-Brometea table

Authors: Silvia Assini, Ilaria Brugellis, Juri Nascimbene, Matteo Barcella, Alessia Gressani, Gabriele Gheza

Data type: xlsx

Link: https://doi.org/10.3897/pls2024612/01.suppl15