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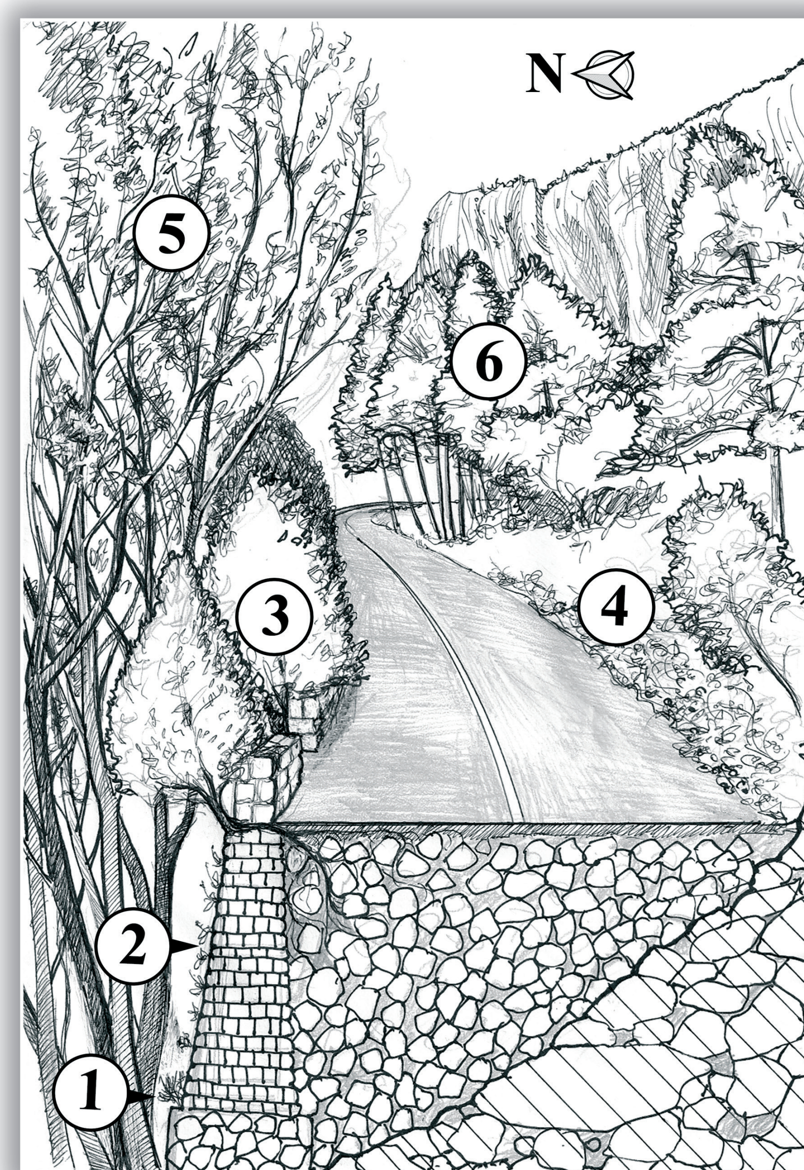

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It publishes original research articles dealing with all aspects of vegetation, from plant community to landscape level, including dynamic processes and community ecology. It favours papers focusing on plant sociology and vegetation survey for developing ecological models, vegetation interpretation, classification and mapping, environmental quality assessment, plant biodiversity management and conservation, EU Annex I habitats interpretation and monitoring, on the ground of rigorous and quantitative measures of physical and biological components.

The journal is open to territorial studies at different geographic scale and accepts contributes dealing with applied research, provided they offer new methodological perspectives and a robust, updated vegetation analysis.

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Cover photo: A schematic transect of the shady-mesic geosigmetum in the suburban area of Monte Pellegrino road system (120 m a.s.l., Palermo, Sicily); for the meaning of the labels, see the caption of Figure 9, page 97, this issue (drawing by Gianguzzi L.).

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Cyperus-dominated vegetation in the eastern Po river

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Abstract

The ephemeral vegetation dominated by *Cyperus* sp. pl. was surveyed and analyzed along the eastern trait of the Po River (Po Plain, Italy). Two formerly described communities were recognized: *Cyperetum esculenti* and *Amaranthus tuberculatus*-phytocoenon. A third greater cluster is assigned to a new association: *Cyperetum micheliano-glomerati*. It is characterized by *Cyperus glomeratus*, *C. michelianus*, *C. odoratus* and *C. squarrosus*, that have been detected on over 75 % of the relevés. The main floristic and ecological traits of these detected vegetation types are discussed.

Keywords

Bidention, *Chenopodion rubri*, *Cyperaceae*, Italy, phytosociology, therophytes

Introduction

The biodiversity changes caused by human activities are global-scale phenomena; invasive alien species (IAS) threat the diversity in the European countries from a biological and ecosystemic perspective. Following the milestone set by the DAISIE Project (an overview is in Lambdon et al. 2008), many European researchers have been involved in expanding the knowledge of local and national invasive alien plants (e.g. for Italy, Galasso et al. 2018). The invasiveness of a single alien species may cause different impacts, due to the different degrees of resistence or resilience shown by habitats and phytocoenoses (Richardson and Pyšek 2006). Nowadays a major challenge is to clarify the impact of invasive alien plants on the natural habitats, merging the data on number and invasiveness of the alien species and relating them to the vulnerability of those habitats.

The Po Plain, in Northern Italy, is one of the European territories most invaded by alien plant species (EEA 2015). The Po river bed acts as habitat corridor, so that many alien pioneer species easily become invasive. Many alien plants are typical of riverine environments and cannot expand beyond the embankments; other ruderal and synanthropic entities are characteristic of the crops, located either between the embankments or out of them, e.g. the poplar clone crops.

Some case studies showed that riparian invasive plants can change the natural habitats: fast-growing trees and shrubs can affect river biodynamics, sedimentation and erosion processes (van Oorschot et al. 2017). Perennial tall herbs as *Reynoutria* spp. and annual vines as *Humulus japonicus* or *Sicyos angulatus* can create dense canopies that outcompete other species (Gerber et al. 2008; Balogh and Dancza 2008; Zhao et al. 2019).

The late summer vegetation of the Po river bed is composed of a set of generalist, nitrophilous species, mixed with other taxa that show peculiar ecological preferences, especially about water availability and substrate texture. These surfaces are free from running waters only for few months or weeks a year: therefore, the plants colonizing them need to start and complete their life cycle during this short time available. The weather trends and the sediments storage caused by floods influence the extent and duration of water-free surfaces from year to year, as well as the cover of late-summer pioneer vegetation. This is a suitable environment for therophytes, like annual *Cyperus* species, *Echinochloa crus-galli*, *Eragrostis pectinacea*, *Lindernia dubia*, *Panicum dichotomiflorum*, *Portulaca oleracea*, *Rorippa palustris*. These taxa release a stable seed stock in the ground, that is ready to germinate as soon as possible (van der Walk 1981; Assini 2001). Despite the relate dynamics of spreading and recolonisation are various and unpredictable, a significant advantage is given by the ability to germinate before the water fully recedes (Abernethy and Willby 1999).

The genus *Cyperus* in Italy includes about 30 species. Many of these are expanding their distribution range, favoured by global warming. These taxa develop late in the season, when the river bed partially emerge from the water due to the decreasing flow, and/or when the waters of the rice-fields are heated enough by the sun. Ten *Cyperus* species grow along the Po river in the study area (Pellizzari and Verloove 2017). Among them *C. flavescens*, *C. fuscus* and *C. michelianus* are native. *C. eragrostis*, *C. odoratus* and *C. squarrosus* are neophytes from tropical America (Petrik 2003; Verloove 2014). *C. microiria* is native to eastern Asia (Verloove 2014). *C. difformis, C. esculentus* and *C. glomeratus* are paleo-subtropical species, native in some Mediterranean areas, but considered as aliens in Italy (Galasso et al. 2018). They are spreading in temperate areas.

This work aims to analyse the ephemeral late-summer vegetation dominated, or mainly characterized, by *Cyperus* sp.pl. Those types are threatened by a pool of Invasive Alien Species (Janssen et al. 2016) and poorly known in the study area. Few types of ephemeral vegetation of river beds are recognized in the Po Plain, representing the main vegetation aspects at the minimum river flow (Sartori and Bracco 1995). These types develop on stretches of the river bed, like oxbows, that are submerged during most of the year, but that in summer are separated from the main course by islands or sand banks, so that they completely dry. Some of these communities are dominated by low-grown species and mainly ascribed to the *Cyperetum flavescentis* (*Nanocyperetalia*, *Isoëto-Nanojuncetea*) (Biondi et al. 1997; 1999; Assini et al. 2010). Other communities are featured by medium and tall-size therophytes and were framed in the *Bidentetalia tripartitae* and *Bidentetea* (Biondi et al. 2003; 2012; Bolpagni 2013b). Outside the Po Plain, the main studies to the hygro-nitrophilous annual vegetation are focused on communities dominated by native species, in which the flatsedges and galingales usually play a minor role (Felzines and Loiseau 2005; de Foucault 2013 a, b; Rennwald 2000; Schneider-Binder 2020). The scheme of Brullo and Minissale (1998) for the Western Palaearctic region needs to be upgraded by a large amount of new data, mainly for France and Spain, but also for the Italian Peninsula (Deil 2005). Only few papers, however, refer to the Po river traits.

Materials and methods

Study area

The Po river stretches for 652 km in Northern Italy, from Western Alps to the Adriatic Sea. It receives the last left tributary (Mincio river) 156 km upstream of the mouth, while the final right-handed tributary (Panaro river) 107 km upstream of the mouth. In this trait the river has flooded six times in the last two centuries (Turitto et al. 2004). After the last disastrous flood occurred in 1951, the main river bed has been permanently embanked and periodically dredged. The bends, banks and oxbows located in the upstream traits of the Po river can foster the natural ephemeral vegetation; the downstream river management as a stabilized channel, partially precludes spatial heterogeneity and habitats diversity (Shankman 1996). The relevés were carried out along the main course of the Po river, between Sermide and Panarella, upstream to the river channelization into the Po Delta branches (Fig. 1).

Figure 1. Study area and relevé locations.

The riverine environment is very homogeneous, due to the stabilization of the embankments, which are over 10 m high. It is distinct from the surrounding plain, lower in elevation and widely ploughed and cultivated. In the final portion of the Po river, two annual maximums are detectable in the water flow, in May and in November, respectively. From the end of May the hydrometric levels start decreasing to the minimum, which is usually reached in August, and then grow back. The decrease in solid transport due to decreasing flow significantly affects the fluvial ecosystem, causing a strong lowering of the river bed, and a widespread coastal erosion by the Adriatic Sea. The restrained summer flow and the increasing groundwater pumping for agricultural and industrial uses have led to the intrusion of salt groundwater up to 20 km in the inland (Tornatore 2008).

Following the application to Italy of the wordlwide bioclimatic classification (Rivas Martinez et al. 2011), the study area belongs to the Temperate (steppic) Macrobioclimate. The Bioclimate shifts from continental westwards to steppic eastwards. The ombrotype is lower subhumid and the thermotype is upper mesotemperate (Pesaresi et al. 2017).

Field survey

132 original relevés were done from August to October 2016, according to the phytosociological approach (Braun-Blanquet 1964; Biondi 2011). Date and location of each relevé are listed in Appendix I. Species names follow the italian checklists (Bartolucci et al. 2018; Galasso et al. 2018). Syntaxonomy follows Biondi et al. (2014).

Data analysis

The species that appeared only in 1 or 2 relevés were removed from the original matrix. The two matrixes were compared through Euclidean distance, then the reduced matrix (132 relevés for 45 species) was subjected to cluster analysis using an average-linkage algorithm in the software Cluster, version 3.0 (Stanford University 1999). The corresponding dendrogram was obtained using Java-TreeView (Saldanha 2004).

To underline the main ecological features of each observed vegetation type, the Ellenberg indicator values were calculated for each obtained cluster, and then the ecograms and the mean indicator values were compared (Pignatti et al. 2005). Life forms (Raunkiaer 1934) and chorological spectra were also calculated for each one of the three groups. The chorotypes follow Pignatti et al. (2017-2019). Archaeophytes (A) and neophytes (N) were detected according to Galasso et al. (2018).

Results

Three main groups were obtained from the cluster analysis, each one corresponding to a distinct vegetation type (Fig. 2).

The groups 1 and 2 are distinct from the last big cluster. The group 1 includes relevés dominated by *Cyperus esculentus*, with a constant presence of *Amaranthus tuberculatus*, *Xanthium italicum* and *Portulaca oleracea* (Tab. 1). This vegetation type develops mainly along the sand bank borders, that are uncovered by the water and hard dried in summer. *C. esculentus* is able to colonize this environment

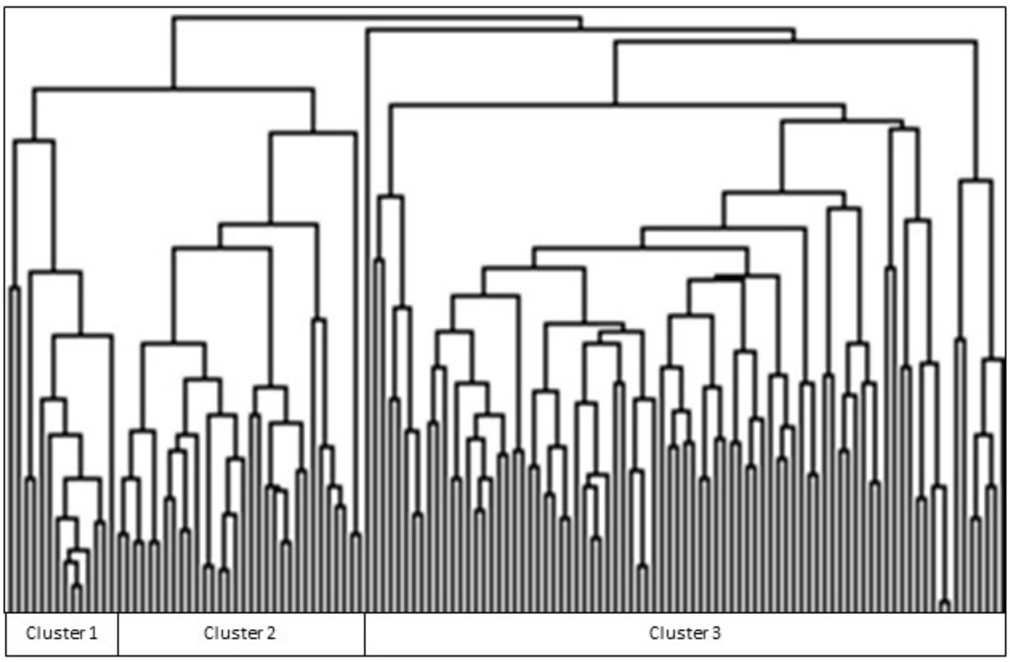

Figure 2. The dendrogram resulting from the cluster analysis. Each group is described in the text.

Table 1. *Cyperetum esculenti* Wisskirchen 1995.

Relevé number	84	49	103	76	67	27	19	21	20	22	34	80	86	47
Cover %	100	80	100	90	70	100	70	80	80	80	80	100	50	90
surface sq.m	8	10	10	8	10	12	4	6	4	8	10	10	8	8
Species number	11	14	11	10	6	7	3	6	4	5	5	6	5	10
Cyperus esculentus L.	4	2	3	4	3	3	4	4	4	4	4	4	3	4
Amaranthus tuberculatus (Moq.) J.D. Sauer	2	1	2	2	.	3	1	2	1	2	2	2	1	2
Xanthium italicum Moretti	1	1	2	3	1	2	.	1	2	2	2	3	1	1
Portulaca oleracea L.	.	1	2	2	1	.	2	+	1	+	2	1	2	1
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	3	2	3	1	1	.	.	.	.	.	1	.	.	.
Cyperus glomeratus L.	2	2	2	2	.	.	.	.	.	.	.	1	.	.
Cyperus squarrosus L.	2	3	1	.	.	1	.	.	.	+	.	.	.	.
Eragrostis pectinacea (Michx.) Nees	.	.	2	2	1	.	.	.	.	.	.	2	2	.
Panicum dichotomiflorum Michx.	1	.	2	2	.	.	.	.	.	.	.	.	.	+
Persicaria lapathifolia (L.) Delarbre	.	.	1	1	.	.	.	1	.	.	.	.	.	1
Cyperus fuscus L.	2	1	1	.	.	.	.	.	.	.	.	.	.	.
Cyperus michelianus (L.) Delile	.	2	.	.	.	+	.	.	.	.	.	.	.	.
Bidens frondosa L.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
Sicyos angulatus L.	.	1	.	.	.	1	.	.	.	.	.	.	.	.
Lindernia dubia (L.) Pennell	+	1	.	.	.	.	.	.	.	.	.	.	.	.
Salix alba L. (pl.)	.	.	.	.	.	+	.	.	.	.	.	.	.	1
Sporadic species	2	2	.	.	1	.	.	1	.	.	.	.	.	3

defending from surface dryness by means of deep and long rhyzomes. These stands develop further high from the water than those of the *Polygono lapathifolii-Xanthietum italici*, which grows in the same sandy substrates (Bolpagni 2013b). Annual flatsedges, like other silty-clay substrate species (e.g. *Lindernia dubia*, *Eclipta prostrata*) are almost absent. These communities are ascribable to the *Cyperetum esculenti*, present in the middle-European river beds, e.g. in Germany (Wisskirchen 1995), and France (Felzines and Loiseau 2005). In Italy it was detected along the Po river in Lombardy and Emilia-Romagna (Bolpagni 2014; Braghiroli e Bolpagni 2016), and along the Tiber river (Lastrucci et al. 2012).

The group 2 gathers 32 relevés dominated by *Amaranthus tuberculatus*, a north-American dioecious amaranth, that has recently become invasive in Italy, where it grows in many disturbed habitats (Iamonico 2015). Its distribution is not influenced by sediment texture, though it often grows on sandy substrates. Similar communities were considered as a form of the pebbly-sandy shore community *Polygono hydropiperis-Bidentetum tripartitae* (Pellizzari 2009). In the present analysis, we follow the attribution to an *Amaranthus tuberculatus*-phytocoenon, characterized by this species and a pool of alien pioneer entities, much of them are typical of *Bidentetalia* (Bolpagni 2013b; Braghiroli and Bolpagni 2016). The cluster is characterized also by the high frequence of four flatsedge species (*Cyperus squarrosus*, *C. michelianus*, *C. esculentus* and *C. odoratus*) (Tab. 2).

The last big cluster (group 3) is interpretable as a single vegetation type, able to grow on medium-fine substrates. This cluster is very homogeneous, especially in its central part. The most frequent species of this group is *Cyperus glomeratus* (100 %), followed by *C. odoratus*, *Echinochloa crus-galli*, *C. michelianus*, *C. squarrosus* and *Amaranthus tuberculatus*, all reaching over 75 %.

The average species number of the whole group results in 11.5; some relevés, to the left side of the group, are slightly different based on the higher average number (12.6), due to the presence of *Amaranthus tuberculatus*, *Eragrostis pectinacea*, *Portulaca oleracea* and other species that document a major disturbance, while other *Cyperus* species play a minor role.

The central part of the cluster represents the typical aspect of the community: *C. odoratus*, *C. michelianus* and *C. squarrosus* may show equal or higher cover than *C. glomeratus*. *Lindernia dubia* and *Panicum dichotomiflorum* are also frequent species, when *Amaranthus tuberculatus* decreases and runs out (Tab. 3).

Given the homogeneity and distictiveness of this big cluster, a new association is described: *Cyperetum micheliano-glomerati* ass. nova *hoc loco* (*Bidention*, *Bidentetalia*, *Bidentetea*). (*Holotypus*: rel. 89* tab. 3, Porporana – FE, 2016 09 12). Its characteristic species are *C. glomeratus*, *C. michelianus*, *C. odoratus*, *C. squarrosus*. The vegetation type appears as therophytic fringes or meadows, which are frequently arranged in two layers. These flatsedge meadows are very dense along the gentle slopes and

Table 2. *Amaranthus tuberculatus* – phytocoenon.

Relevé number	31	28	30	29	41	40	18	14	6	7	45	25	24	26	23	13	3	43	44	32	33	35	36	38	39	59	8	17	4	1	62	61
Cover %	100	80	90	90	90	80	100	90	90	100	90	90	80	90	80	90	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Surface sq.m	12	20	12	20	8	6	8	10	10	10	10	12	10	10	12	10	10	10	8	16	14	12	10	12	12	6	10	10	10	10	16	12
Species number	12	10	13	11	8	10	5	8	9	7	11	6	6	8	7	3	9	13	10	13	11	8	11	8	10	11	5	5	7	7	8	9
Amaranthus tuberculatus (Moq.) J.D. Sauer	4	3	4	4	3	2	2	2	2	3	2	3	3	4	4	5	3	3	3	2	3	3	2	2	2	1	1	4	3	4	5	5
Cyperus michelianus (L.) Delile	1	1	2	1	2	2	1	2	2	2	2	.	.	2	2	1	1	2	1	2	1	2	1	3	3	4	5	3	4	2	1	1
Cyperus squarrosus L.	2	2	2	1	2	3	3	3	3	3	3	4	3	2	1	1	2	1	1	3	2	2	2	3	3	.	.	.	.	.	1	2
Cyperus esculentus L.	2	1	1	1	2	2	3	3	1	2	2	1	1	1	1	.	.	1	.	1	2	1	1	.	.	.	.	.	.	.	.	.
Cyperus odoratus L.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1	3	4	3	1	3	4	3	2	1	1	.	1	+	.	1
Species of higher syntaxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	1	.	.	.	+	1	.	.	1	1	+	.	.	.	.	.	1	2	.	1	+	.	+	.	+	2	.	1	+	1	.	.
Rorippa palustris (L.) Besser	1	2	1	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	.	.	.	.	.	.
Persicaria lapathifolia (L.) Delarbre	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	1	2	2	1	1	+	.	.	.	.	+	.	.	.
Bidens frondosa L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	1	1	.	+	.	1	+	+	.	.	1	.	.
Xanthium italicum Moretti	.	.	.	.	.	.	+	.	.	.	.	.	.	1	1	.	1	1	1	+	.	.	.	.	.	1	.	.	.	.	.	.
Cyperus glomeratus L.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	2	2
Persicaria maculosa Gray	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2
Lycopus europaeus L.	1	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.
Rorippa prostrata (J.P.Bergeret) Schinz & Thell.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	1	.	1	.	.	.	.	.	.	.
Ranunculus sceleratus L.	+	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens vulgata Greene	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Panicum dichotomiflorum Michx.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Bidens connata Muhl. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Mollugo verticillata L.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Portulaca oleracea L.	1	+	1	+	3	2	.	.	.	.	.	.	.	.	.	.	+	1	.	1	2	2	2	1	2	.	+	.	.	.	.	.
Lindernia dubia (L.) Pennell	+	.	1	1	1	2	.	.	.	.	1	.	.	.	.	.	.	1	1	1	1	1	1	2	1	1	.	.	.	.	.	.
Salix alba L. (pl.)	.	.	.	.	.	.	.	1	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	2
Paspalum distichum L.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Artemisia annua L.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.
Lythrum salicaria L.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eclipta prostrata (L.) L.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 2. Continuation.

Relevé number	31	28	30	29	41	40	18	14	6	7	45	25	24	26	23	13	3	43	44	32	33	35	36	38	39	59	8	17	4	1	62	61
Cover %	100	80	90	90	90	80	100	90	90	100	90	90	80	90	80	90	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Surface sq.m	12	20	12	20	8	6	8	10	10	10	10	12	10	10	12	10	10	10	8	16	14	12	10	12	12	6	10	10	10	10	16	12
Species number	12	10	13	11	8	10	5	8	9	7	11	6	6	8	7	3	9	13	10	13	11	8	11	8	10	11	5	5	7	7	8	9
Sicyos angulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Ludwigia peploides (Kunth) P.H.Raven subsp. *montevidensis* (Spreng.) P.H.Raven	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium album L. subsp. *album*	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	1	.	2	.	.	1	.	.	.	.	2	.	1	.	.	.	1	1	1	.	.	.	.	.	.	1	.	.	.	.	.	.

sparser on the dry bottom of the oxbows, marked by the characteristic polygonal muds. The upper level contacts of the community are often several communities of *Bidention* or *Chenopodion rubri*, such as the *Amaranthus tuberculatus*-phytocoenon or the *Cyperetum esculenti*, whilst the lower level contacts are carpets of *Eclipta prostrata*, *Lindernia dubia* or rarely *Ludwigia peploides* subsp. *montevidensis*. These reptohelophytic species tend to grow also into a shallow water layer.

The main ecological traits of the observed vegetation types are confirmed by the comparison of the mean Ellenberg values calculated for each group of relevés (Tab. 4). The ecograms are basically similar, with all the vegetation types showing high values for light, temperature and moisture; the indicator values for continentality, soil reaction and nutrients are lower (Fig. 3). The *Amaranthus tuberculatus*-phytocoenon shows the highest N value (6.25), due to the presence of a pool of summer-annual weeds, that also colonize crops and poplar plantations of the Po plain.

The *Cyperetum micheliano-glomerati* shows the highest moisture index (7.89). It is characterized also by high light and temperature, due to its tendency to grow in the lowest parts of the dried river bed, that are far from temporary shading effects.

The three recognized vegetation types show the typical traits of the pioneer ephemeral vegetation, as it is clearly showed by the life form spectra, that are dominated by therophytes (Fig. 4). *Cyperus glomeratus*, often a helophyte in reedbeds, behaves as annual in the surveyed environments, spreading from the spring seed stock. The bar graph data include the sporadic species. If these are neglected, the therophyte rate rises on *Cyperetum micheliano-glomerati* from 64% to 89.2%.

In the chorological spectra, neophytes are the main groups (*Cyperetum esculenti* 52%; *Amaranthus*-phytocoenon 43.6%; *Cyperetum micheliano-glomerati* 45.3%), but also the other major groups have a wide distribution (Cosmopolitan/Subcosmopolitan, Eurasian incl. Palaeotemperate) (Fig. 5).

Discussion and conclusions

Both *Cyperetum esculenti* and *Amaranthus tuberculatus*-phytocoenon, as the above mentioned *Polygono-Xanthietum*, *Polygono-Chenopodietum* known from Lombardy (Sartori and Bracco 1995; Assini et al. 2010) and *Echinochloo-Polygonetum lapathifolii* known from Tuscany (Lastrucci et al. 2014), are included in the *Chenopodion rubri* of *Bidentetalia* and *Bidentetea tripartitae*. Felzines and Loiseau (2005) suggest to divide the *Chenopodion rubri* in three sub-alliances. One of these, *Eragrostienion pilosae*, is also characterized by *Cyperus esculentus* and *Eragrostis pectinacea*, and includes the *Cyperetum esculenti*.

The *Amaranthus tuberculatus*-phytocoenon could provide the basis for the description of a new association, dominated by the wide spectrum weed *A. tuberculatus*,

Table 3. *Cyperetum micheliano-glomerati* ass. nova (part I).

Relevé number	117	85	73	74	102	121	120	119	107	108	70	104	69	89*	105	72	65	106	79	99	83	71	42	127	58	56	57
Cover %	100	90	100	100	90	100	90	80	100	90	100	100	100	90	100	100	90	100	100	80	100	100	100	100	100	90	100
Surface sq.m	4	10	8	12	8	10	10	8	20	10	8	14	10	10	10	14	12	20	20	10	12	12	12	16	16	12	12
Species number	13	15	11	15	13	14	12	8	13	14	11	13	16	12	14	9	12	13	10	18	14	12	10	11	7	7	8
Character species																											
Cyperus glomeratus L.	3	4	3	3	3	4	3	3	4	2	3	4	4	3	4	4	3	4	5	3	4	2	3	2	2	3	2
Cyperus odoratus L.	2	1	.	1	1	1	.	.	2	3	2	2	2	2	2	3	2	2	2	2	3	3	2	2	3	2	2
Cyperus michelianus (L.) Delile	1	1	1	.	.	1	.	.	1	2	1	2	2	2	2	2	2	2	1	2	2	3	3	4	4	4	3
Cyperus squarrosus L.	.	2	2	.	1	1	2	2	2	1	2	2	2	1	2	1	1	1	.	1	1	2	2	2	1	1	2
Alliance, order, class species																											
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	1	.	2	2	.	2	2	1	1	1	.	1	+	1	2	1	2	2	2	+	2	2	1	1	1	+	.
Amaranthus tuberculatus (Moq.) J.D. Sauer	1	3	4	2	2	3	2	2	.	.	1	1	2	1	1	1	2	1	2	2	2	1	2	+	.	1	2
Lindernia dubia (L.) Pennell	.	1	.	1	2	.	.	.	1	2	1	1	1	2	2	2	2	1	2	2	2	2	1	+	.	.	.
Panicum dichotomiflorum Michx.	2	+	2	1	1	.	.	.	+	1	.	1	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.
Xanthium italicum Moretti	.	.	.	2	1	.	+	.	+	.	2	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Portulaca oleracea L.	.	.	2	2	3	2	+	2	.	.	.	1	+	.	.	.	+	.	.	+	.	+	.	1	.	.	.
Persicaria lapathifolia (L.) Delarbre	1	.	.	1	+	1	+	1	.	.	.	.	.	+	.	.	1	+	1	.	.	.	.	.	.	.	.
Cyperus esculentus L.	.	.	.	2	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Bidens vulgata Greene	1	.	1	.	.	+	.	.	1	+	+	.	.	.	+	.	.	+	+	1	.	2	1	.	.	.	.
Artemisia annua L.	.	+	+	+	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.
Bidens connata Muhl. ex Willd.	+	.	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.
Rorippa palustris (L.) Besser	.	+	1	.	.	+	.	.	.	1	.	.	+	.	+	.	.	.	.	2	1	.	+	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Bidens frondosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus L.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	+	.	.	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																											
Cyperus fuscus L.	1	1	.	2	2	2	3	3	4	3	2	2	2	2	1	2	2	4	3	1	1	1	.	.	.	.	.
Eragrostis pectinacea (Michx.) Nees	.	2	1	3	1	2	2	2	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salix alba L. (pl.)	.	.	.	.	.	.	.	.	1	.	.	2	1	.	1	.	.	2	.	2	1	.	.	.	.	2	1
Cyperus difformis L.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	+	.	.	.
Cyperus microiria Steud.	.	.	.	1	1	2	1	.	.	1	1	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Eclipta prostrata (L.) L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.
Ammannia coccinea Rottb.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Sicyos angulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Sporadic species	2	3	.	.	.	.	1	.	1	1	.	.	2	1	3	.	.	.	.	1	.	1	1	.	2	.	1

Table 3. *Cyperetum micheliano-glomerati* ass. nova (part II).

Relevé number	109	111	63	64	46	48	50	66	54	55	81	75	116	95	101	98	94	93	92	91	113	100	110	96	97	60	82	115
Cover %	100	70	80	90	100	100	90	70	100	100	90	90	90	90	90	100	100	95	100	100	100	90	100	100	100	100	100	100
Surface sq.m	12	10	8	12	8	10	14	10	10	14	10	10	6	12	10	12	16	10	12	16	14	10	12	14	16	20	14	16
Species number	12	9	7	10	14	12	11	10	7	8	10	13	15	15	13	15	13	13	12	15	13	17	11	15	13	6	11	14
Character species																												
Cyperus glomeratus L.	2	2	3	3	2	1	2	3	3	2	3	3	3	3	2	3	3	2	2	3	2	3	2	3	4	3	3	2
Cyperus odoratus L.	3	1	1	2	1	2	1	.	.	.	.	1	3	3	2	2	2	2	1	2	3	2	2	2	1	2	3	3
Cyperus michelianus (L.) Delile	2	2	.	1	1	3	2	2	4	3	3	2	1	2	1	1	4	4	5	2	1	1	4	2	3	1	3	3
Cyperus squarrosus L.	3	3	2	3	2	2	2	2	1	2	2	2	2	2	1	3	.	1	.	1	4	2	2	1	2	.	.	1
Alliance, order, class species																												
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	2	1	2	2	2	2	3	+	1	1	2	1	1	1	2	2	2	3	2	2	+	1	2	2	2	2	1	2
Amaranthus tuberculatus (Moq.) J.D. Sauer	2	2	2	2	3	3	2	2	2	3	3	2	2	2	1	2	1	2	1	3	2	2	1	2	1	4	3	2
Lindernia dubia (L.) Pennell	.	+	2	2	1	1	1	1	+	+	1	.	1	1	2	1	1	1	2	2	1	2	.	1	2	.	1	1
Panicum dichotomiflorum Michx.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	1	2	1	+	.	1	2	1	2	2	2	2	2	2	1
Xanthium italicum Moretti	1	.	.	.	1	.	.	.	.	.	.	1	+	.	+	1	1	+	+	1	1	1	1	1	1	.	2	+
Portulaca oleracea L.	1	+	1	1	1	2	.	+	.	.	.	1	1	+	.	1	+	.	.	1	.	.	.	.	.	.	.	+
Persicaria lapathifolia (L.) Delarbre	1	1	.	+	1	.	.	.	.	.	.	1	+	1	+	1	1	1	2	2	2	1	1	1	1	.	1	1
Cyperus esculentus L.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	2	1	2	1	.	.	.
Bidens vulgata Greene	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2	2	+	1	1	.	1	1
Artemisia annua L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens connata Muhl. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	1	1	.	.	.	.	.	.
Rorippa palustris (L.) Besser	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.
Bidens frondosa L.	.	.	.	.	.	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																												
Cyperus fuscus L.	1	.	.	1	+	1	2	.	.	.	1	1	1	1	3	3	2	1	2	2	.	1	.	1	3	.	.	.
Eragrostis pectinacea (Michx.) Nees	.	.	.	.	.	1	1	1	.	.	.	3	.	2	1	2	.	.	+	1	.	.	.	.	.	.	.	.
Salix alba L. (pl.)	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyperus difformis L.	.	.	.	.	.	.	2	.	.	.	.	.	1	1	1	.	2	1	.	.	.	.	.	1	.	.	.	1
Cyperus microiria Steud.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1	1	1	.	1	.	.	.	.	.	.
Eclipta prostrata (L.) L.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2
Ammannia coccinea Rottb.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sicyos angulatus L.	.	.	.	.	.	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 3. *Cyperetum micheliano-glomerati* ass. nova (part III).

Relevé number	90	52	51	53	68	136	134	130	131	133	128	126	78	77	129	132	11	12	10	15	16	114	112	135	125	124	123	122
Cover %	100	100	90	100	70	90	100	80	100	100	100	100	100	100	100	80	80	100	75	90	90	100	100	80	80	100	100	90
Surface sq.m	12	16	20	10	12	12	10	12	16	12	16	20	12	10	14	10	10	10	8	8	8	10	10	10	10	12	8	10
Species number	9	15	14	11	11	14	13	11	12	11	13	9	12	7	12	10	11	9	5	4	4	14	13	12	10	10	8	14
Character species																												
Cyperus glomeratus L.	2	3	2	3	3	4	1	3	2	3	2	1	5	5	4	4	4	4	3	4	4	2	3	2	2	1	1	2
Cyperus odoratus L.	3	2	2	3	2	2	3	3	2	2	1	1	2	1	3	2	.	.	.	1	1	2	2	3	3	2	4	3
Cyperus michelianus (L.) Delile	3	2	3	2	1	3	2	2	4	4	5	5	1	.	2	.	1	.	1	2	1	.	1	.	.	.	.	.
Cyperus squarrosus L.	.	1	1	.	2	2	4	2	4	.	2	2	.	.	1	1	.	.	.	.	.	3	.	4	4	5	4	3
Alliance, order, class species																												
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	2	2	1	2	.	.	3	2	1	2	1	.	3	3	1	.	2	1	.	.	.	1	1	2	1	2	2	2
Amaranthus tuberculatus (Moq.) J.D. Sauer	3	2	2	2	1	.	+	.	.	.	+	.	1	.	+	.	.	1	.	.	.	2	2	.	.	.	.	.
Lindernia dubia (L.) Pennell	2	1	1	1	.	+	1	+	.	+	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panicum dichotomiflorum Michx.	1	.	.	.	.	.	2	1	1	2	2	1	2	1	2	1	.	.	.	.	.	3	3	1	1	2	3	2
Xanthium italicum Moretti	.	1	2	+	1	+	2	1	2	1	2	+	.	1	.	.	.	.	.	.	.	3	2	1	1	2	1	1
Portulaca oleracea L.	.	1	1	1	+	1	1	.	1	+	+	1	1	.	.	.	.	.	.	.	.	.	1	1	1	1	+	1
Persicaria lapathifolia (L.) Delarbre	2	1	.	.	.	+	.	.	.	1	1	.	.	1	.	.	.	.	.	.	.	1	1	.	.	.	1	1
Cyperus esculentus L.	.	2	2	1	.	.	1	1	+	.	1	.	.	.	.	.	1	1	1	1	1	2	2	1	.	1	.	1
Bidens vulgata Greene	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.
Artemisia annua L.	.	+	.	.	.	1	1	1	.	+	+	1	.	.	1	1	.	.	.	.	.	.	.	+	.	.	.	.
Bidens connata Muhl. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Rorippa palustris (L.) Besser	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	1	.	1	+	.	.	.	.	.	+	2	1	+	.	.	.	.	.	.	.	+	.	.
Bidens frondosa L.	.	.	+	.	.	.	.	.	.	.	.	.	5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	.	.	.	1	.	.	.	+	.	.
Other species																												
Cyperus fuscus L.	.	.	1	2	.	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
Eragrostis pectinacea (Michx.) Nees	.	2	2	2	2	1	.	.	1	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Salix alba L. (pl.)	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	+	1	+	2	.	.	.	.	.	.	.	.	.
Cyperus difformis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	2	.	.	2
Cyperus microiria Steud.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2
Eclipta prostrata (L.) L.	.	.	+	.	.	+	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.
Ammannia coccinea Rottb.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	.	.	.	.	.
Sicyos angulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	1	2	.	.	2	1	1	.	.	.	.	.	.	.	.	.	5	3	1	.	.	.	.	1	1	.	.	1

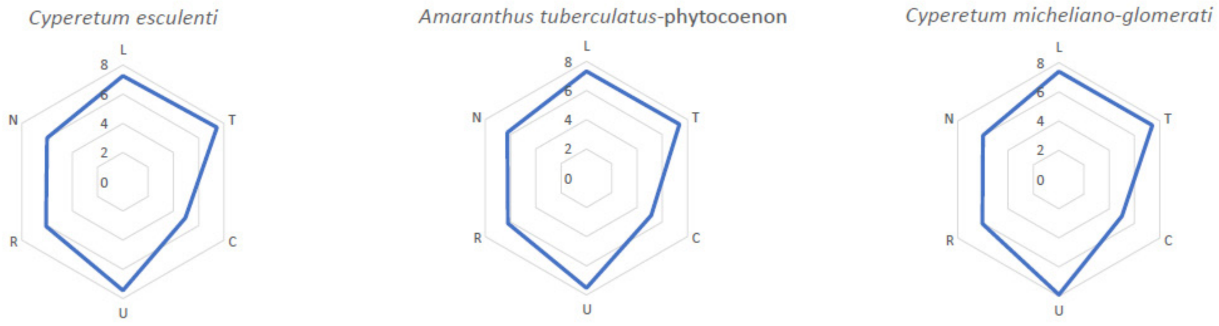

Figure 3. Ecograms for the three vegetation types detected through the analysis.

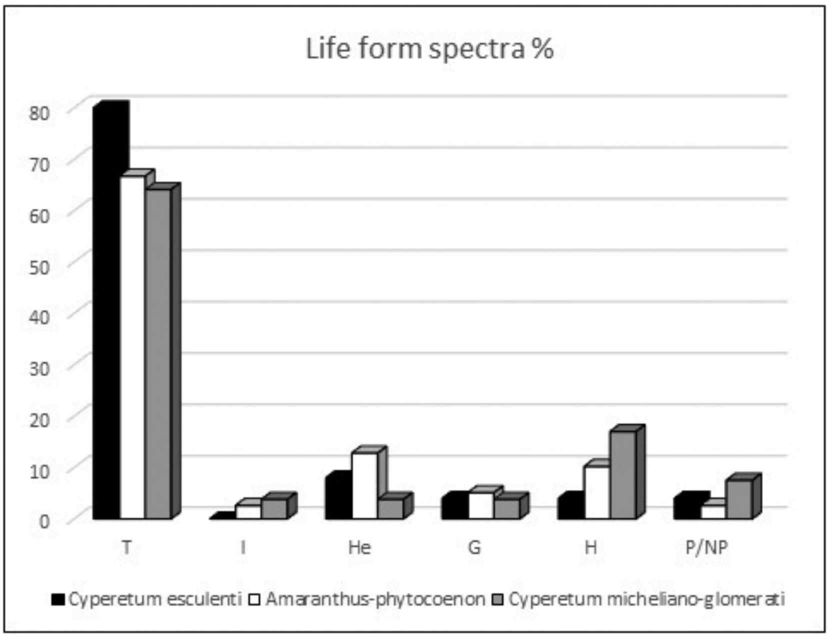

Figure 4. Life forms spectra of the three vegetation types detected through the analysis.

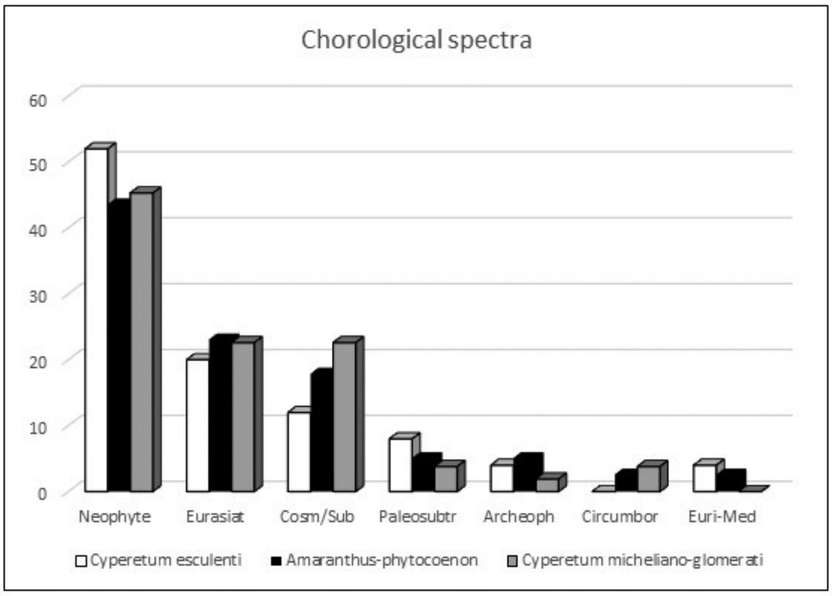

Figure 5. Chorological spectra of the three vegetation types detected through the analysis.

Table 4. Mean values of the Ellenberg-Pignatti Indexes for the three groups .

	L	T	C	U	R	N
Cyperetum esculenti	7.25	7.44	4.93	7.44	6.08	6
Amaranthus tuberculatus-phytocoenon	7.32	7.36	5.12	7.52	6.21	6.25
Cyperetum micheliano-glomerati	7.39	7.4	5	7.89	6.04	6

but it is difficult to identify a clear combination of constant species. Due to its size (sometimes over 2 m) and invasiveness, that weed outcompetes the dominant and characteristic species of all *Bidention*-communities, whose cover values seem underestimated. *C. michelianus* and *C. squarrosus* are able to grow under the thick layers of *Amaranthus*, unlike, for instance, *C. glomeratus*. To assign this community to a subassociation or variant of *Polygono hydropiperis-Bidentetum tripartitae* could mean to underrate the role of *A. tuberculatus*; conversely, to tipify a new association could mean too emphasize it. The relatively low number of *Bidention* different communities is related to a large variation of each type, under the aspect of species composition, physiognomy and anthropic pressures (Neacşu and Arsene 2017). Further data and a comparison with other situations outside of the river bed (such as crops or disturbed areas, in which *A. tuberculatus* is equally invasive), are needed for the institution of a new syntaxon (Costea et al. 2005).

The palaeosubtropical species *Cyperus glomeratus* and *C. michelianus* give the name to the newly described association *Cyperetum micheliano-glomerati*, for which also the American neophytes *C. odoratus* and *C. squarrosus* are listed as character species. The highlighting of the palaeosubtropical entities (Fig. 5) is seen as an opportunity for reconsidering the status of *Cyperus glomeratus* compared to *C. michelianus*. Both are native from Eastern European/Western Asian areals, and nowadays the first is also considered native in Italy by Euro+Med Database (Jimenez-Mejas and Luceño 2011) and IUCN (Kavak 2014). The European distribution ranges of the first two flatsedges are considerably overlapping. Outside Europe, *C. michelianus* is nowadays widespread in Africa and southern Asia (Lansdown 2014), while *C. glomeratus* is common further north, up to Korea and Japan (Kavak 2014). Linnaeus (1756) described *C. glomeratus* based on an Italian specimen (Peruzzi et al. 2008); *C. australis* Schrad. is a later synonymous of *C. glomeratus* (Govaerts and Simpson 2007). The species was widespread, although rare, and not strictly linked to rice fields. Indeed, this habitat favoured different species as *C. difformis* and *C. fuscus*, both assigned to subgenus *Anosporum*: their C3 photosynthetic pathway gives them an ecological advantage in habitats flooded for long time (Matsunaka 1983; Pellizzari and Verloove 2017).

C. glomeratus has a wide ecological amplitude. In addition to the presence in the studied late summer vegetation, it plays an active role in building helophytic fringes of *Phragmition*, along rivers and around lakes, in fresh or brackish waters (Bragato et al. 2006; Biondi et al. 2009). Along the Chienti river (Marche), a *C. glomeratus*-dominated community was framed into the *Magnocaricion* (Crisanti and Taffetani 2015). Another *C. glomeratus*-community found along the Po river was framed into the *Chenopodion rubri* (Sartori and Bracco 1996; Pellizzari 2009; Assini et al. 2010). Other *C. glomeratus*-dominated communities were ascribed either to the *Bidention* or to the *Nanocyperion*, e.g. along the Po river up to the Venetian Delta (Marconato et al. 2014). At Lake Pistono (Piedmont), some seasonally flooded muddy shores host flatsedge communities: *Cyperetum flavescentis* close to the water and a *Bidention*-community with *C. glomeratus* in less flooded sites (Tisi et al. 2007). A *C. glomeratus*-community of *Nanocyperion* can be found in two sites in Lombardy; it is dominated by *C. glomeratus*, *C. fuscus* and *C. michelianus* (FLA 2008). In these cases native species are dominant, unlike along the Po river. In Slovakia, *C. glomeratus* was reported in the Danube river beds in the middle 19th century, and was recently rediscovered in few sites. Here the species characterizes an ephemeral, two-layered vegetation type, with features of both *Nanocyperion* and *Bidention*, interpreted as a highly ruderal facies of *Cyperetum micheliani* (see below: Meleckova et al. 2016). Downstream along the Danube river, from the Eastern Wallachia to the Delta, both *C. glomeratus* and *C. michelianus* are characteristic of the macrophytes riparian vegetation (Stankovic et al. 2015).

The second characteristic species of *Cyperetum micheliano-glomerati* is another linnean species from Italy, *Cyperus michelianus*. It is diagnostic of several European plant communities. Lacking of Western taxa, some of these (*Cyperetum micheliani*, *Lindernio–Dichostylidetum michelianae*) are clearly continental, known from Central and Eastern Europe (Trpin et al. 1996; Jasprica et al. 2003; Šumberová 2011; Dubina et al. 2015). Except for *Cyperus fuscus*, the diagnostic species of *Cyperetum micheliani* sensu Šumberová (2013) are rare or completely missing along the Po river. Other communities characterized by *C. michelianus* develop in the Atlanto-Mediterranean range, i.e. in France and Spain (Corillion 1971; de Foucault 2013b; Cochard et Guitton 2014; Renaux 2014; Rivas-Martinez et al. 1980 ; Camacho et al. 2009). In Emilia-Romagna, along and near the Secchia river, the *Crypsio schoenoidis-Cyperetum micheliani* grows on silty-clay soils (EGPB Emilia Centrale 2013). Within the study area of this work, a *C. michelianus*-community of *Heleochloo-Cyperion* was detected at first (Pellizzari 2009). Based on the results of this study, it can be assigned to the new described association, that reports in the same habitat *C. glomeratus* and *C. michelianus* together with *C. squarrosus* and *C. odoratus*. The last one peculiar species was recently discovered during an investigation of the Po river bed, and in several herbarium specimen (Verloove 2014). In particular, some of them were correctly identified after a former attribution to *Cyperus strigosus* (Lastrucci et al. 2016; Pellizzari and Verloove 2017). *C. odoratus* is naturalizing at least in three different European areas (Verloove 2014): a) the Po river in Italy; b) along the Danube river in Serbia, and in its Delta in Romania (Anastasiu and Negrean 2006); c) in NE Spain, along the Segre river down to the confluence with the Ebro. Nowadays *C. odoratus* is rather common in the Po river beds of Lombardy (Galasso and Banfi 2015), Emilia-Romagna (Verloove 2014), Veneto (Masin et al. 2015) and Tuscany (Lastrucci et al. 2016; 2017).

The last species, *C. squarrosus*, reached the Po plain in the late 19th century (Cavara 1899), but its spread began in the muddy river beds and ponds only in the last years (Bolpagni 2013 a,b).

Despite a resemblance with the *Cyperetum micheliani* identified along the Danube river in Slovakia and Hungary, the *Cyperetum micheliano-glomerati* is rather different. In fact, the communities that grow along the Po river have a higher total cover (often 100 %) and are characterised by a pool of *Cyperus* species. This is a peculiarity of such vegetation. Along the Po river, near Mantua, no aspects simultaneously dominated by different *Cyperus* species were found: similar situations were dominated by a larger neophyte set, mainly composed by graminoid grasses (*Echinochloa crus-galli*, *Panicum* sp. pl., *Paspalum distichum*) (Bolpagni 2013b). The only abundant flatsedge was *C. squarrosus*, and that suggested to frame those communities, in which *C. glomeratus* and *C. difformis* played a minor role, in the *Nanocyperion*. Communities of the *Nanocyperion flavescentis* are composed of native species and clearly different from the newly typified community. Here, only *C. flavescens* is characteristic of alliance, while *C. fuscus* and *C. michelianus* are characteristic of order (Brullo and Minissale 1998).

The following observations support the inclusion of the *Cyperetum micheliano-glomerati* in the *Bidention* (*Bidentetea*):

1. A major role, together with *Cyperus* spp., played by characteristic species of *Bidention* and of higher syntaxonomic units (*Echinochloa crus-galli*, *Amaranthus tuberculatus*, *Lindernia dubia*, *Persicaria lapathifolia*, *Panicum dichotomiflorum*, *Bidens connata*, *B. frondosa*, etc.);
2. The alien origin of some pioneer species, that witness both high soil eutrophication and disturbance of the regular flooding, able to carry seed stocks;
3. The fine particle size of silty-clay substrates, compared with that of contact communities of *Chenopodion rubri*.

According to Biondi et al. (2012), communities of *Cyperetum micheliano-glomerati* are referable to the habitat 3270 "Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation" (CORINE Biotopes 22.33 and 24.52; EUNIS C3.52 and C3.53). In Italy this habitat is widespread and typically invaded by alien plants, much of which are of tropical and subtropical origin (Zivkovic and Biondi 2010). The next goal will be to clarify the synecology of these alien, often invasive entities (Assini et al. 2010).

The human impacts drastically changed the final stretch of the Po River bed, so that it is very homogeneous and artificial. The late summer ephemeral vegetation is easily replaced by long-lasting secondary vegetation or directly destructed. That underlines the rareness and fragility of such habitat (Bolpagni 2013b; Ditetova et al. 2016). The typified *Bidention*-community expresses an aspect of conservation interest, in spite of its alien species richness. Anyway it is lower, if compared with the other aspects framed in the *Chenopodion rubri*. The *Cyperetum micheliano-glomerati* preserves the natural traits and plays an important ecological role when compared to the artificially managed river beds and river banks.

Syntaxonomic scheme

BIDENTETEA TRIPARTITAE Tüxen, Lohmeyer et Preising ex von Rochow 1951
BIDENTETALIA TRIPARTITAE Br.-Bl. et Tüxen ex Klika in Klika et Hadač 1944
Chenopodion rubri (Tüxen 1960) Hilbig et Jage 1972
Eragrostienion pilosae Felzines et Loiseau 2005
Cyperetum esculenti Wisskirchen 1995 [cluster 1]
Amaranthus tuberculatus-phytocoenon Bolpagni 2013 [cluster 2]
Bidention tripartitae Nordhagen 1940 em. Tüxen in Poli et J. Tüxen 1960
Cyperetum micheliano-glomerati ass. nova [cluster 3]

Other syntaxa quoted in the text

Crypsio schoenoidis–Cyperetum micheliani Martinez Parras, Peinado Lorca, Bartolomé Esteban et Molero Mesa 1988; *Cyperetum flavescentis* W. Koch ex Aichinger 1933; *Cyperetum micheliani* Horvatic 1931; *Echinochloo–Polygonetum lapathifolii* Soó et Csürös 1974; *Lindernio–Dichostylidetum michelianae* Slavnic 1951; *Nanocyperion flavescentis* Koch ex Libbert 1932; *Polygono-Chenopodietum* Lohmeyer 1970; *Cyperus glomeratus*-variant; *Polygono hydropiperis–Bidentetum tripartitae* Lohm. in Tüxen 1950; *Polygono lapathifolii–Xanthietum italici* Pirola et Rossetti 1974.

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Appendixes

Appendix I - Site and date of the phytosociological relevés (WGS 84)

Rels. 1-17: 08/08/2016; Pontelagoscuro, FE; Latitude N 44°53'08.65, Longitude E 11°37'37.31.

Rels. 18-22: 08/08/2016; S. Maria Maddalena, RO; Latitude N 44°53'27.07, Longitude E 11°36'00.31.

Rels. 23-27: 10/08/2016; Francolino, FE; Latitude N 44°53'41.31, Longitude E 11°38'44.29.

Rels. 28-31: 10/08/2016; Guarda Ferrarese, FE; Latitude N 44°57'40.63, Longitude E 11°46'53.75.

Rels. 32-39: 16/08/2016; Between Polesella and Canaro, RO; Latitude N 44°56'22.19, Longitude E 11°44'28.77.

Rels. 40-41: 16/08/2016; Guarda Veneta, RO; Latitude N 44°58'37.86, Longitude E 11°48'00.81.

Rels. 42-44: 25/08/2016; Zocca, FE; Latitude N 44°55'40.14, Longitude E 11°44'30.25.

Rels. 45-53: 25/08/2016; Cologna, FE; Latitude N 44°58'24.80, Longitude E 11°55'01.79.

Rels. 54-60: 25/08/2016; Coronella di Cologna, FE; Latitude N 44°58'23.23, Longitude E 11°52'54.72.

Rels. 61-62: 30/08/2016; Stienta, RO; Latitude N 44°56'22.94, Longitude E 11°31'52.45.

Rels. 63-65: 30/08/2016; Gaiba (Surchio W), RO; Latitude N 44°56'23.50, Longitude E 11°29'25.68.

Rels. 66-68: 30/08/2016; Gaiba sand bank, RO; Latitude N 44°56'24.36, Longitude E 11°29'38.69.

Rels. 69-72: 30/08/2016; Gaiba (Surchio E), RO; Latitude N 44°56'26.02, Longitude E 11°29'42.84.

Rel. 73: 05/09/2016; Crespino, RO; Latitude N 44°58'34.37, Longitude E 11°52'32.52.

Rels. 74-83: 05/09/2016; Canalnovo, RO; Latitude N 44°58'54.23, Longitude E 11°56'40.00.

Rel. 84: 05/09/2016; Villanova Marchesana, RO; Latitude N 44°59'19.04, Longitude E 11°57'50.18.

Rels. 85-86: 05/09/2016; Panarella, RO; Latitude N 44°58'54.36, Longitude E 12°04'29.79.

Rels. 89-101: 12/09/2016; Porporana (oxbow W), FE; Latitude N 44°56'01.32, Longitude E 11°27'54.69.

Rels. 102-103: 12/09/2016; Porporana riva Po, FE; Latitude N 44°56'03.30, Longitude E 11°27'46.64.

Rels. 104-118: 12/09/2016; Porporana (oxbow E), FE; Latitude N 44°56'06.64, Longitude E 11°28'28.58.

Rels. 119-122: 29/09/2016; Quatrelle, MN; Latitude N 44°57'16.84, Longitude E 11°25'28.87.

Rels. 123-136: 29/09/2016; Sermide, MN; Latitude N 45°00'24.66, Longitude E 11°18'21.31.

Appendix II - Sporadic species

Table 1: *Cyperetum esculenti*

Rel. 84: *Bidens vulgata* 1; *Artemisia annua* +.

Rel. 49: *Eclipta prostrata* 1; *Lycopus europaeus* 1.

Rel. 67: *Persicaria maculosa* 2.

Rel. 21: *Polygonum arenastrum* +.

Rel. 47: *Digitaria sanguinalis* 2; *Paspalum distichum* 2; *Cyperus odoratus* 1.

Table 2: *Amaranthus tuberculatus*-phytocoenon

Rel. 31: *Amaranthus blitum* +.

Rel. 30: *Abutilon theofrasti* +; *Heteranthera reniformis* +.

Rel. 40: *Atriplex prostrata* 1.

Rel. 45: *Urtica dioica* 1; *Veronica* cfr. *peregrina* +.

Rel. 24: *Phalaris arundinacea* 1.

Rel. 3: *Phragmites australis* +.

Rel. 43: *Polygonum arenastrum* +.
Rel. 44: *Convolvulus sepium* 1.
Rel. 59: *Eragrostis pectinacea* 2.

Table 3: *Cyperetum glomerato-micheliani*

Rel. 117: *Bidens cernua* 3; *Ludwigia peploides* 2; *Eclipta prostrata* 1.
Rel. 85: *Cyperus flavescens* 1; *Urtica dioica* 1; *Amorpha fruticosa* (pl.) +; *Ranunculus sceleratus* +.
Rel. 120: *Cyperus difformis* 1; *Veronica beccabunga* +.
Rel. 107: *Mentha aquatica* +.
Rel. 108: *Mentha aquatica* 1.
Rel. 69: *Mollugo verticillata* +; *Persicaria maculosa* +.
Rel. 89: *Rorippa sylvestris* 2.
Rel. 105: *Alisma plantago-aquatica* +; *Heteranthera reniformis* +; *Veronica anagallis-aquatica* +.
Rel. 99: *Veronica anagallis-aquatica* +.
Rel. 71: *Humulus japonicus* 1.
Rel. 42: *Persicaria maculosa* 1.
Rel. 58: *Phalaris arundinacea* +; *Rubus caesius* +.
Rel. 57: *Phalaris arundinacea* 1.
Rel. 46: *Chenopodium album* 1; *Digitaria sanguinalis* 1; *Solanum nigrum* 1.
Rel. 90: *Rorippa sylvestris* +.
Rel. 52: *Digitaria sanguinalis* 2; *Cyperus eragrostis* 1.
Rel. 68: *Digitaria sanguinalis* 2; *Mollugo verticillata* 1.
Rel. 136: *Mollugo verticillata* 1.
Rel. 134: *Bidens tripartita* 1.
Rel. 11: *Juncus effusus* 1; *Lythrum salicaria* 1; *Paspalum distichum* 1; *Phalaris arundinacea* 1; *Populus canadensis* (pl.) 1.
Rel. 12: *Lythrum salicaria* 2; *Phalaris arundinacea* 2; *Paspalum distichum* 1.
Rel. 10: *Populus canadensis* (pl.) 1.
Rel. 135: *Urtica dioica* +.
Rel. 125: *Urtica dioica* +.
Rel. 122: *Persicaria maculosa* +.

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PENSOFT.

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A novel insight into the remnants of hygrophilous forests and scrubs of the Po Plain biogeographical transition area (Northern Italy)

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Abstract

Hygrophilous forests and scrubs are ecotonal habitats providing essential ecosystem services, especially in human-modified landscapes; nevertheless, they are among the most threatened habitats worldwide. A sound knowledge of waterside woody vegetation provides a valuable basis for interventions of renaturation of waterbodies. This paper focuses on peculiar communities that occur in riparian and swamp areas of the Po Plain, a broad ecotonal area between the Mediterranean and Temperate regions. The study allowed the description of six new associations. Moreover, it provides a detailed picture of *Dioscoreo communis-Populetum nigrae* (*Populetalia albae*) and *Amorpho fruticosae-Salicetum albae* (*Salicetalia purpureae*), an overview of *Salicetum triandrae* (*Salicetalia purpureae*) at the national and European level, and an update of the alliance *Dioscoreo-Ulmion minoris*, which is better characterized, classified in *Populetalia albae* and enlarged to include five associations of elm-oak-rich forests of the Po Plain lowlands and the Karst. *Dioscoreo-Ulmion* includes, besides *Lamio orvalae-Ulmetum minoris*, also *Polygonato-Quercetum roboris* and three new associations: *Vinco minoris-Ulmetum minoris* and *Salvio glutinosae-Quercetum roboris* from Po Plain rivers and the karstic lakeshore *Rhamno catharticae-Ulmetum minoris*. The new arrangement of *Dioscoreo-Ulmion* results from an analysis of Po Plain elm-rich forests including stands so far attributed to the critical alliance *Alnion incanae*; the presence of *Querco-Ulmetum minoris* in Italy is discussed. Two new associations are attributed to *Prunetalia spinosae*: *Salici eleagni-Juniperetum communis* and *Ulmo minoris-Paliuretum spinae-christi*. Stands from the Rivers Isonzo and Tagliamento referred to *Veratro nigri-Fraxinetum excelsioris* and to the new association *Carici albae-Fraxinetum excelsioris* represent the outermost expressions of the *Ostryo-Tilion* ravine forests extending towards the High Plain. A *Salix alba* swamp forest, *Galio palustris-Salicetum albae*, is reported for the first time in Italy and attributed to *Alnetea glutinosae*.

Keywords

karst lakes, Po Plain, riparian vegetation, swamp vegetation, syntaxonomy, wet scrubs, wet woodlands

Introduction

Areas adjacent to rivers, lakes and other inland water bodies encompass complex ecosystems with a definitely ecotonal character between the truly aquatic and terrestrial habitats; they are characterized by distinctive abiotic and biotic conditions strongly influenced by the water, and are particularly sensitive to environmental change (Naiman and Décamps 1997; Verry et al. 2000; Naiman et al. 2005). These highly dynamic transitional zones provide a multitude of fundamental ecosystem services such as maintaining biodiversity, high primary productivity, transfer of materials and energy between terrestrial and aquatic ecosystems, nutrient filtering, flood-protection and reduction of natural disaster risks, water availability and quality improvement, climate change mitigation, recreation (see e.g. Tockner and Ward 1999; Ewel et al. 2001; Naiman et al. 2005; Hale and Adams 2007; Dimopoulos and Zogaris 2008; Strayer and Findlay 2010; Riis et al. 2020). Indeed, freshwater marginal areas and in particular riparian woodlands associated with river systems in human-altered landscapes could be considered as "keystone habitats" for biodiversity conservation, because they provide support to a large number of native species, structure biotic communities and help drive ecosystem functions with an importance far beyond their real, typically reduced extent (Dudgeon 2000; Parrott and MacKenzie 2000; Boutin et al. 2003; Jobin et al. 2004; McKinstry et al. 2004; Lovell and Sullivan 2006; Dimopoulos and Zogaris 2008; Wantzen et al. 2008). The Habitats Directive 92/43/EEC regards rivers and their riparian areas as landscape features essential to maintain biological connections, while the Water Framework Directive (2000/60/EC) recognizes the value of riparian and shore zones as hydromorphological quality elements for surface water bodies (European Commission 2003). Despite their ecological and economic remarkable value wet habitats bordering water bodies are among the most human-altered and threatened habitat types worldwide.

Waterside habitats play a major role in biodiversity conservation in intensive agricultural landscapes because they represent remnants of both wetland and woody habitats available for wildlife (Jobin et al. 2004). The Po Plain is one of the most important industrial and agricultural areas in Europe, and one of the most human-altered as well: the Po Plain landscape has been almost completely altered by centuries of human presence.

From the bioclimatic and biogeographical point of view, the Po Plain constitutes a broad ecotonal band interposed between the Mediterranean and the Temperate regions. It is recognized in the classification of the ecoregions of Italy as one of the 7 Provinces of Italy, namely the "Po Plain" Province (Blasi et al. 2014), and corresponds to the Padanian sector of the Biogeographic Map of Europe (Rivas-Martínez et al. 2004). Due to its geographic position, it has experienced, and has been shaped by, the effects of two main migratory routes of species, one lying along a south-north axis and the other along an east-west one. Although it lies within the Temperate macroclimate, its transitional bioclimatic character is shown by the fact that it largely belongs to ecotonal bioclimatic variants, namely the Submediterranean and Steppic variants according to Rivas-Martínez et al. (2011), with Submediterraneity features *sensu lato* (Pesaresi et al. 2017). The eastern part of the Po Plain area, corresponding to the Venetian-Friulian Plain, does not show values of the Submediterraneity index to be included in one of the two aforementioned variants (Pesaresi et al. 2017); nevertheless, with its ecological and biogeographical features, it still belongs to a transition, Temperate-Mediterranean ecoregion, and is often considered in the literature as submediterranean in a broad sense (see e.g. Mucina et al. 2016).

Riparian and swamp communities have a strong azonal character: indeed they are mainly conditioned by the water regime, hydrodynamics and soil features, and to a lesser extent by macrobioclimatic characteristics. As a result, variations occur only with marked macrobioclimatic changes (Biondi et al. 2004). However, the preconception that hygrophilous azonal vegetation is little influenced by the biogeographical context has led to the uncritical use of names of communities described from Central Europe for plant assemblages of the Po Plain, without an evaluation of their floristic and biogeographical content (Poldini et al. 2011; Sburlino et al. 2011). Indeed, in the past, the treatment of Po Plain hygrophilous woodlands and scrubs used to be performed adopting Central European syntaxa. To solve these problems of large-scale ecotonal variations of hygrophilous forest communities, in the recent literature new syntaxa have been already introduced at the level of alliances, such as *Ligustro vulgaris-Alnion glutinosae*, *Frangulo alni-Fraxinion oxycarpae* (Biondi et al. 2015), *Dioscoreo communis-Populion nigrae*, *Dioscoreo-Ulmion minoris* (Poldini et al. 2017).

The aim of this paper is to discuss some peculiar hygrophilous and meso-hygrophilous woodlands and scrubs associated with lotic and lentic freshwater water bodies of the Po Plain. These communities often represent what little remains of the natural habitats in the current intensive agricultural, industrial and densely populated areas of the Po Plain landscape. We therefore address the issue of clarifying the syntaxonomic position of various woody hygrophilous communities, many of which at least potentially widespread, of this broad ecotonal area between the Mediterranean and Temperate regions, complying with the basic ecological distinction between hygrophilous communities of flowing and standing waters.

The heavy human impacts in the Po Plain result also in a high level of hemeroby in hygrophilous communities: indeed, invasive exotic plants are one of the major threats to biodiversity in this area (Assini et al. 2010; Poldini et al. 2011). Consequently, woody communities undergo human-induced regression and degradation, up to the substitution of physiognomically relevant elements in the extreme cases. A further problem addressed in this paper is that of the need to use invasive transformer species in the syntaxonomic treatment of plant coenoses because of the considerable modification of the characteristics of riparian communities, which are particularly exposed to the effect of alien species (e.g. Richardson et al. 2007; Schnitzler et al. 2007). In this work therefore some syntaxonomic units are defined also using naturalized alien species.

This paper aims to fill a gap of knowledge about riparian and swamp woody vegetation in the Po Plain area, including the Karst sector, and to provide basic knowledge to produce reference schemes for interventions of restoration of wet habitats in order to preserve their ecological and biogeographical specificities.

Materials and methods

The analysis was carried out on published and unpublished phytosociological relevés of peculiar hygrophilous and meso-hygrophilous riverine, lakeshore and swamp communities from lowland areas of Friuli Venezia Giulia, Veneto, Lombardy, Piedmont, Emilia Romagna (Po Plain), and also Tuscany, classified by their authors or here assigned into the orders *Alnetalia glutinosae* (*Alnetea glutinosae*), *Populetalia albae* (*Alno glutinosae-Populetea albae*), *Salicetalia purpureae* (*Salicetea purpureae*), *Fagetalia sylvaticae* (*Querco-Fagetea*) and *Prunetalia spinosae* (*Rhamno-Prunetea*).

Relevés of plant communities were carried out according to the Braun-Blanquet (1964) approach and organized in a database. For a better treatment of some syntaxa, the relevés from the Po Plain were compared to published data (synthetic tables) from various areas of Italy and Europe.

Statistical analyses were performed using SYN-TAX 2000 (Podani 2001). The main community types were analised separately, by means of agglomerative hierarchical clustering using Similarity ratio as the resemblance measure, and Principal Component Analysis (PCA, covariance method).

The analysis of the matrices of relevés and species was performed on cover data, which were transformed according to Van der Maarel (1979). Analytic tables were arranged according to the results of the hierarchical clustering. Sporadic species (i.e. occurring in 1 relevé of an analytic table) were excluded from statistical processing.

When considered appropriate to characterize a syntaxon, the synthetic tables of the Po Plain communities derived from the analytic ones were compared by means of multivariate analysis with those of coenoses from other parts of Italy and/or Europe. The analyses of synthetic tables were based on percentage frequency values; species occurring with a frequency less than 20% were excluded from data processing.

Data concerning the analytic tables are quoted in the Appendices. The sources of the relevés and the original syntaxa names of the communities in the synoptic tables are listed in their captions.

Syntaxonomic nomenclature up to the level of alliance follows Biondi et al. (2014b) and further updates by Biondi and Blasi (2015), except for the class *Salici purpureae-Populetea nigrae* that is substituted by *Alno glutinosae-Populetea albae* in order to include only forest communities, and the alliances *Ostryo carpinifoliae-Tilion platyphylli* and *Fraxino excelsioris-Acerion pseudoplatani*, which are in accordance with Mucina et al. (2016). The phytosociological nomenclature follows Weber et al. (2000), taking also into account Theurillat et al. (2020). Communities are presented according to the syntaxonomic hierarchy.

Diagnostic entities of vegetation classes fundamentally follow Mucina et al. (2016) and Aeschimann et al. (2004). For the identification of the diagnostic species of the associations, the entities having frequency classes from V to III in the synthetic tables were considered. The concept of differential species is in accordance with Mucina (1993) and Biondi (2011).

Taxonomic nomenclature follows Bartolucci et al. (2018) and Galasso et al. (2018), with the exception of *Asarum europaeum*, for which we maintain the distinction of the subsp. *caucasicum*, which replaces the nominal subspecies in southern European regions (Fischer et al. 2008). Subspecies are indicated in the text only when they are different from the nominal subspecies or when one or several subspecies occur besides the nominal one.

The correspondence of syntaxa with habitats of the 92/43/EEC Habitats Directive follows the European Interpretation Manual (European Commission 2013) and Biondi et al. (2009, 2012).

The analysis considered relevés from the following bodies of water of Italy. Rivers/streams: Adda, Brenta, But, Isonzo, Oglio, Piave, Po, Scrivia, Sesia, Stella, Stirone, Tagliamento, Tanaro, Taro, Ticino and Trebbia, along with Aventino, Fino, Pescara, Saline, Sangro, Serchio and Tavo considered in the analytic table of *Salicetum triandrae*. Lakes: Idro, Viverone, the karst lakes Doberdò, Pietrarossa, Sablici and Mucille, artificial lakes near Fucecchio marshes (lake of "Bosco Poggioni"), lakes of the area "Cinque laghi di Ivrea". Marshland in the Regional Park of the Po Delta.

Geomorphological terminology referring to watercourses follows Siligardi et al. (2007).

The bioclimatic characterization is in accordance with Rivas-Martínez (2008), Rivas-Martínez et al. (2011) and follows Pesaresi et al. (2017). However, the term "submediterranean" is here used in a broad sense, often adopted in the literature for transition areas with a tendency of summer aridity, including the areas of the Po Plain lying in the Submediterranean and Steppic bioclimatic variants (with positive values of the Submediterraneity Index), as well as areas of the Venetian-Friulian Plain, which belong to other variants of the Temperate macrobioclimate according to Pesaresi et al. (2017).

Results and discussion

Scrubs of the class *Rhamno-Prunetea*

Ass.: *SALICI ELEAGNI-JUNIPERETUM COMMUNIS* Poldini, Francescato, Vidali & Castello *ass. nov*. (Tab. 1)

Holotypus: rel. 2 of Tab. 1 in this paper.

Diagnostic species: *Salix eleagnos*, *Achnatherum calamagrostis*, *Carex alba*, *Pinus nigra* subsp. *nigra*, *Pinus sylvestris*, *Populus nigra*, *Gypsophila repens*, *Hippophaë fluviatilis*.

Structure and composition: Dense, rather impenetrable scrub, dominated by *Juniperus communis*, *Salix eleagnos*, *Fraxinus ornus* accompanied by *Hippophaë fluviatilis*, *Ligustrum vulgare* and many other shrubs, along with sin-

Table 1. *Salici eleagni-Juniperetum communis ass. nov*. Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Complete linkage).

Relevé number	1	2*	3	4	
Altitude (m a.s.l.)	170	173	181	68	
Area (m^2)	100	80	80	70	
No. of species	29	20	20	28	Fr.
Diagnostic species of the association					
Salix eleagnos Scop.	1	2	1	2	100
Achnatherum calamagrostis (L.) P.Beauv.	1	1	1	+	100
Carex alba Scop.	3	2	+	2	100
Pinus nigra J.F.Arnold subsp. *nigra*	1	.	1	1	75
Pinus sylvestris L.	2	.	+	+	75
Populus nigra L.	1	1	1	.	75
Gypsophila repens L.	+	+	+	.	75
Hippophaë fluviatilis (Soest) Rivas Mart.	.	+	2	+	75
Species of *Fraxino orni-Berberidenion*					
Fraxinus ornus L. subsp. *ornus*	1	2	2	2	100
Ostrya carpinifolia Scop.	1	+	+	1	100
Emerus major Mill. s.l.	.	.	+	.	25
Species of *Rhamno-Prunetea* and *Prunetalia spinosae*					
Juniperus communis L.	3	4	3	1	100
Ligustrum vulgare L.	1	1	1	1	100
Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó)	+	.	.	+	50
Crataegus monogyna Jacq.	+	.	.	+	50
Hedera helix L. subsp. *helix*	+	.	.	+	50
Viburnum lantana L.	+	.	.	+	50
Clematis vitalba L.	.	.	+	.	25
Berberis vulgaris L.	.	.	.	+	25
Dealpine species					
Centaurea jacea L. subsp. *gaudinii* (Boiss. & Reut.) Gremli	+	+	+	+	100
Sesleria caerulea (L.) Ard. subsp. *caerulea*	.	+	1	2	75
Buphthalmum salicifolium L.	+	+	.	.	50
Centaurea scabiosa L. subsp. *fritschii* (Hayek) Hayek	+	+	.	.	50
Melica nutans L.	+	.	.	+	50
Petasites paradoxus (Retz.) Baumg.	.	+	.	+	50
Tommasinia altissima (Mill.) Reduron	.	+	+	.	50
Other species					
Euphorbia cyparissias L.	+	+	.	.	50
Artemisia alba Turra	+	.	.	.	25
Carex digitata L.	+	.	.	.	25
Cephalanthera longifolia (L.) Fritsch	+	.	.	.	25
Frangula alnus Mill. subsp. *alnus*	+	.	.	.	25
Helianthemum nummularium (L.) Mill. subsp. *obscurum* (Čelak.) Holub	+	.	.	.	25
Molinia arundinacea Schrank	+	.	.	.	25
Quercus pubescens Willd. subsp. *pubescens* (pl.)	+	.	.	.	25
Quercus robur L. subsp. *robur*	+	.	.	.	25
Solidago virgaurea L.	+	.	.	.	25
Bromopsis condensata (Hack.) Holub s.l.	.	+	.	.	25
Carex liparocarpos Gaudin subsp. *liparocarpos*	.	+	.	.	25
Lomelosia graminifolia (L.) Greuter & Burdet subsp. *graminifolia*	.	+	.	.	25
Aster amellus L.	.	.	+	.	25
Carduus defloratus L. subsp. *sumanus* (Pollini) Arcang.	.	.	+	.	25
Polygonatum odoratum (Mill.) Druce	.	.	+	.	25
Amelanchier ovalis Medik.	.	.	.	1	25
Carex flacca Schreb. s.l.	.	.	.	+	25
Cervaria rivini Gaertn.	.	.	.	+	25
Cornus mas L.	.	.	.	+	25
Corylus avellana L.	.	.	.	+	25
Dioscorea communis (L.) Caddik et Wilkin	.	.	.	+	25
Hepatica nobilis Mill.	.	.	.	+	25
Siler montanum Crantz subsp. *montanum*	.	.	.	+	25
Sorbus aria (aggr.)	.	.	.	+	25

gle small trees of *Pinus nigra* and *P. sylvestris*. The herbaceous layer is characterized by *Achnatherum calamagrostis* and *Carex alba*. *Juniperus communis* occurs with plants up to 4 m tall, with very elongated, down-curved, pendulous branches and rather long and spaced needles, corresponding to the controversial var. *intermedia* (Schur) Sanio, found in the submontane and montane areas in the foreland of South-Eastern Alps.

Syntaxonomy: The assignment to *Rhamno-Prunetea* is provided by the high incidence of shrubs of this class; the community is included in the endemic suball. *Fraxino orni-Berberidenion* for the high frequency of *Ostrya carpinifolia* and *Fraxinus ornus*. Compared to the other associations of this suballiance distributed from the South-Eastern Alps to the Dinarides, *Salici-Juniperetum* stands out for the entities related to soil moisture and loose gravel deposits correlated to fluvisols, and the strong dealpinism. The occurrence of glareicolous elements of *Thlaspietea rotundifolii* (*Achnatherum calamagrostis*, *Gypsophila repens*, *Lomelosia graminifolia*, *Petasites paradoxus*) in a community of *Rhamno-Prunetea* should be highlighted. It is a riverside ecotonal shrub community between the classes *Rhamno-Prunetea* and *Salicetea purpureae*.

Salici-Juniperetum differs from the analogous scrubs with *Hippophaë fluviatilis* described from Italy for the absence of *Quercetea ilicis* species differential of *Pruno-Rubion ulmifolii* (Tab. 2). *Spartio juncei-Hippophaetum fluviatilis* (col. 3 in Tab. 2) is a mantle vegetation of riparian woods on pebbly-gravelly substrates of recent terraces described from the River Taro (Emilia-Romagna region) by Biondi et al. (1997), which is differentiated by species with southern European distribution of the alliance *Cytision sessilifolii*, while *Junipero-Hippophaetum fluviatilis* (*Pruno-Rubion ulmifolii*) (cols 1, 2) is typical of the dune habitats of the North-Adriatic coasts (Géhu et al. 1984; Gamper et al. 2008). These thermophilous communities are both rich in *Quercetea ilicis* elements. The peculiar position of *Salici-Juniperetum* (col. 4) is given also by the presence of several dealpine species. Finally, *Salici-Juniperetum* is similar to the Central European *Hippophao-Berberidetum* (*Berberidion*) (col. 5), of which it constitutes the phytogeographical parallelism south of the Alps, being differentiated by the large presence of *Juniperus communis*, the scarcity of *Berberis vulgaris* and the high incidence of southern elements (*Fraxinus ornus*, *Ostrya carpinifolia*, etc.).

Compared to *Salici incanae-Hippophaetum*, a community of river gravel banks dominated by *Hippophaë fluviatilis* included in *Salicetea purpureae* and reported from Friuli Venezia Giulia by Oriolo and Poldini (2002), the new association is readily distinguished physiognomically by the prevalence of *Juniperus communis* and the absence of *Salix daphnoides* and *S. purpurea*.

Synecology: It grows on primitive, cobble-gravel soils on recent low river terraces subject to episodic flooding. It is found at about 100 m a.s.l., in the middle course and in the last part of the upper course of the River Tagliamento. Compared to the other scrub communities of river gravels it represents the least wet term. It is therefore possible to identify a sequence of scrub communities ordered along a gradient of decreasing soil moisture represented by *Salicetum incano-purpureae*, *Salici-Hippophaetum* and *Salici-Juniperetum*, establishing a typical topographic-catenal sequence.

Dynamic contacts: It may perhaps represent the result of the evolution of *Stipetum calamagrostis* and the initial stages of shrub encroachment of *Centaureo dichroanthae-Globularietum cordifoliae* (*Festuco-Brometea*).

Catenal contacts: In contact with pioneer communities of *Epilobio-Scrophularietum caninae*, communities with *Xanthium italicum* and elements of *Dauco-Melilotion* (*Artemisietea*).

Synchorology: Upper and middle course of the River Tagliamento, from Venzone to Valvasone (Friuli Venezia Giulia) (Suppl. material 1, Fig. S1), in the Temperate macrobioclimate, oceanic variant, upper mesotemperate to lower supratemperate thermotypes and lower humid to upper humid ombrotypes (according to Pesaresi et al. 2017).

Annex I Habitat (92/43/EEC Directive): 3240.

Ass.: *ULMO MINORIS-PALIURETUM SPINAE-CHRISTI* Poldini & Vidali *ass. nov*. (Tab. 3)

Holotypus: rel. 8 of Tab. 3 in this paper.

Corresponding names: “Fitocenon a *Paliurus spina-christi* e *Ulmus minor*” in Poldini and Vidali (1995); *Rubo ulmifolii-Ligustretum vulgare rubetosum caesii* Poldini 1989.

Diagnostic species: *Ulmus minor* subsp. *minor*, *Rubus caesius*.

Structure and composition: Medium-tall, dense scrub characterized by *Ulmus minor*, always occurring as a shrub, *Rubus caesius* and *Paliurus spina-christi*, generally accompanied by *Rhamnus cathartica*, *Prunus spinosa*, *Crataegus monogyna*, *Cornus sanguinea* subsp. *hungarica* and *Ligustrum vulgare*. The dense shrub layer overshadows the undergrowth, and the herbaceous layer is poorly developed. The cover of *Ulmus minor* and *Paliurus spina-christi* follows the gradient of soil moisture with an inverse trend: where *Ulmus minor* is more frequent, *Paliurus spina-christi* decreases and vice versa.

Syntaxonomy: This community was interpreted by Poldini and Vidali (1995) and Poldini et al. (2002a) as a hygrophilous mantle connected to termophilous hedgerows included in the alliance *Berberidion vulgaris* (*Prunetalia spinosae*) and attributed to *Fraxino orni-Berberidenion*, a suballiance which is characterized by a mixture of Mediterranean, Central-European and Illyrian elements and represents a transition between the Central European *Berberidenion* and the Mediterranean *Pruno-Rubion ulmifolii*. In their treatment of the class *Rhamno-Prunetea* in Italy, Poldini et al. (2002b) included the community in the submesophilous coenoses of *Fraxino orni-Berberidenion*, encompassing the mantles of mesophilous and submeso-hygrophilous mixed deciduous forests.

Biondi (1999) suggested a possible inclusion of this community in *Pruno spinosae-Rubion ulmifolii* (*Pyro spi-*

Table 2. Simplified synoptic table of gravel river banks and dune scrub communities with *Hippophaë fluviatilis* of *Rhamno-Prunetea* arranged according to a biogeographical gradient. Species with frequency < 40 % are not reported in the table, except those with phytosociological significance. 1: *Junipero-Hippophaetum fluviatilis* (Géhu et al. 1984); 2: *Junipero-Hippophaetum fluviatilis* (Gamper et al. 2008); 3: *Spartio juncei-Hippophaetum fluviatilis typicum* (Biondi et al. 1997); 4: *Salici eleagni-Juniperetum communis ass. nov.*; 5: *Hippophao-Berberidetum* (orig. Tab. 4, col. 9 by Exner and Willner 2007a, 2007b).

Number of column	1	2	3	4	5
Number of relevés	10	7	10	4	50
Species of *Rhamno-Prunetea* and *Prunetalia spinosae*					
Ligustrum vulgare L.	90	57.1	50	100	88
Crataegus monogyna Jacq.	60	42.9	90	50	82
Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó)	20	14.3	60	50	86
Juniperus communis L.	90	100	.	100	8
Viburnum lantana L.	30	.	10	50	68
Rhamnus cathartica L.	50	100	10	.	56
Rosa canina L. (s.str.)	10	14.3	90	.	22
Clematis vitalba L.	.	.	70	25	32
Hedera helix L. subsp. *helix*	.	.	.	50	.
Species of *Pruno-Rubion ulmifolii*					
Rubus ulmifolius Schott (*R. fruticosus* aggr.)	90	100	80	.	.
Asparagus acutifolius L.	100	100	.	.	.
Rubia peregrina L.	100	100	.	.	.
Pyracantha coccinea M.Roem.	70	57.1	.	.	.
Lonicera etrusca Santi	70	42.9	.	.	.
Clematis flammula L.	**90**	.	.	.	.
Quercus ilex L. subsp. *ilex*	**40**	.	.	.	.
Phillyrea latifolia L.	**40**	.	.	.	.
Pinus pinea L. (cult.)	**40**	.	.	.	.
Phillyrea angustifolia L.	.	**57.1**	.	.	.
Species of *Cytision*					
Spartium junceum L.	.	.	**50**	.	.
Colutea arborescens L.	.	.	20	.	.
Cytisophyllum sessilifolium (L.) O.Lang	.	.	10	.	.
Species of *Fraxino orni-Berberidenion*					
Fraxinus ornus L. subsp. *ornus*	.	.	30	**100**	.
Ostrya carpinifolia Scop.	.	.	20	**100**	.
Emerus major Mill. s.l.	.	.	30	25	.
Species of *Berberidenion*					
Berberis vulgaris L.	20	.	.	25	**68**
Lonicera xylosteum L.	.	.	.	.	**62**
Deapennine species					
Artemisia alba Turra	.	.	**50**	.	.
Bromopsis erecta (Huds.) Fourr.	.	.	**50**	.	.
Dealpine species					
Carex alba Scop.	.	.	.	**100**	40
Melica nutans L.	.	.	.	**50**	48
Pinus sylvestris L.	.	.	.	**75**	32
Pinus nigra J.F.Arnold subsp. *nigra*	.	.	.	**75**	.
Achnatherum calamagrostis (L.) P.Beauv.	.	.	.	**100**	.
Centaurea jacea L. subsp. *gaudinii* (Boiss. & Reut.) Gremli	.	.	.	**100**	.
Sesleria caerulea (L.) Ard. subsp. *caerulea*	.	.	.	**75**	.
Gypsophila repens L.	.	.	.	**75**	.
Buphthalmum salicifolium L.	.	.	.	**50**	6
Centaurea scabiosa L. subsp. *fritschii* (Hayek) Hayek	.	.	.	**50**	8
Petasites paradoxus (Retz.) Baumg.	.	.	.	**50**	.
Tommasinia altissima (Mill.) Reduron	.	.	.	**50**	.
Other hygrophilous shrubs					
Hippophaë fluviatilis (Soest) Rivas Mart.	90	71.4	100	75	44
Frangula alnus Mill. subsp. *alnus*	30	.	20	25	50
Populus nigra L.	20	.	20	75	40
Rubus caesius L.	10	14.3	.	.	46
Salix eleagnos Scop.	.	.	30	100	66
Salix purpurea L. s.l.	.	.	40	.	72
Other species					
Teucrium chamaedrys L. subsp. *chamaedrys*	100	71.4	10	.	2
Calamagrostis epigejos (L.) Roth subsp. *epigejos*	50	.	.	.	30

Table 2. Continuation.

Number of column	1	2	3	4	5
Number of relevés	10	7	10	4	50
Silene vulgaris (Moench) Garcke subsp. *tenoreana* (Colla) Soldano & F.Conti	90	100	.	.	.
Carex liparocarpos Gaudin subsp. *liparocarpos*	.	57.1	.	25	.
Euphorbia cyparissias L.	.	.	10	50	40
Quercus robur L. subsp. *robur*	10	.	.	25	52
Fraxinus excelsior L. subsp. *excelsior*	.	.	.	.	**54**
Galium mollugo (aggr.)	.	.	.	.	**40**

Table 3. *Ulmo minoris-Paliuretum spinae-christi ass. nov*. Relevés are arranged according to cluster analysis (cover data, Similarity ratio, UPGMA). B: shrub layer.

Relevé number		1	2	3	4	5	6	7	8*	
Area (m²)		70	60	60	50	60	80	80	60	
No. of species		13	15	12	12	12	23	13	16	Fr.
Diagnostic species of association										
Ulmus minor Mill. subsp. *minor*	B	4	2	2	1	2	1	2	1	100
Rubus caesius L.		2	+	2	2	2	+	.	+	88
Species of *Fraxino orni-Berberidenion*										
Cornus sanguinea L. subsp. *hungarica* (Kárpáti) Soó		1	1	1	2	1	3	1	.	88
Fraxinus ornus L. subsp. *ornus*	B	.	.	.	.	1	2	2	1	50
Xanthoselinum venetum (Spreng.) Soldano & Banfi		.	.	+	.	1	.	.	.	25
Cotinus coggygria Scop.		.	.	.	.	.	1	+	.	25
Frangula rupestris (Scop.) Schur		.	.	.	.	+	.	.	.	13
Species of *Prunetalia*										
Rhamnus cathartica L.		1	1	3	2	.	+	+	1	88
Prunus spinosa L. subsp. *spinosa*		3	3	2	2	.	1	.	1	75
Ligustrum vulgare L.		2	2	1	2	.	1	.	2	75
Euonymus europaeus L.		.	1	1	1	2	+	.	+	75
Hedera helix L. subsp. *helix*		.	+	.	.	.	2	+	.	38
Prunus mahaleb L. s.l.		.	.	.	.	2	+	1	.	38
Acer campestre L.		.	+	.	.	2	.	.	.	25
Species of *Rhamno-Prunetea*										
Paliurus spina-christi Mill.		1	1	+	1	.	3	3	4	88
Rubus ulmifolius Schott + ser. *Discolores* P.J. Müll.		1	1	.	.	.	2	1	.	50
Crataegus monogyna Jacq.		1	.	2	1	.	1	1	+	75
Rosa canina L.		1	.	+	.	1	+	1	+	75
Clematis vitalba L.		.	.	.	.	.	2	.	.	13
Other species										
Quercus pubescens Willd. subsp. *pubescens*		+	+	.	.	1	+	.	.	50
Viola reichenbachiana Jord. ex Boreau		1	+	.	+	.	.	.	+	50
Asparagus tenuifolius Lam.		.	+	+	+	.	.	.	.	38
Sesleria autumnalis (Scop.) F.W.Schultz		.	+	.	.	.	+	1	.	38
Campanula trachelium L. subsp. *trachelium*		+	.	.	+	.	.	.	.	25
Brachypodium sylvaticum (Huds.) P. Beauv.		.	.	.	.	.	+	.	2	25
Celtis australis L. subsp. *australis*	B	.	.	.	.	.	+	.	+	25
Dactylis glomerata L.		.	.	.	.	.	+	+	.	25
Salvia glutinosa L.		.	.	.	.	+	.	.	.	13
Asparagus acutifolius L.		.	.	.	.	.	+	.	.	13
Ruscus aculeatus L.		.	.	.	.	.	+	.	.	13
Galium mollugo L.		.	.	.	.	.	.	.	+	13
Aristolochia clematitis L.		.	.	.	.	.	.	.	+	13
Clematis viticella L.		.	.	.	.	.	.	.	+	13

nosae-Rubetalia ulmifolii), including termophilous Mediterranean and submediterranean scrub communities with abundant *Rubus ulmifolius* occurring on moist soils and characterized by the presence of a large group of Mediterranean species (Biondi et al. 2014a; Biondi and Blasi 2015). The coenosis was not analysed in the subsequent revision of the *Paliurus spina-christi*-dominated vegetation of Europe by Casavecchia et al. (2015) because of the limited cover values of *Paliurus spina-christi* in the relevès published by Poldini and Vidali (1995).

Due to the preponderance of Illyric submediterranean xeric elements and the scarceness of Mediterranean elements the coenosis is maintained within the suballiance *Fraxino orni-Berberidenion*, of which it represents the least arid element of transition towards *Pruno-Rubion*. We therefore prefer to maintain the position discussed in Poldini et al. (2002a), which point out that the arrangement in *Pruno-Rubion* suggested by Biondi (1999) could be accepted from an ecological point of view, but it is not supported by floristic features.

Synecology: It is found in the highest areas of the banks of the karstic Lake Doberdò which are subject to episodic floods, representing the outermost situation influenced by the presence of water. It is an Illyric submediterranean thermophilous meso-hygrophilous scrub community that constitutes the landward mantle of the meso-hygrophilous *Rhamno catharticae-Ulmetum minoris* woodland introduced in this paper. Two aspects can be distinguished: a more hygrophilous one with abundant *Ulmus minor*, *Rubus caesius* and *Rhamnus cathartica*, and a more arid one dominated by *Paliurus spina-christi*, *Fraxinus ornus* and other elements of *Prunetalia*.

Dynamic contacts: In dynamic contact with *Rhamno catharticae-Ulmetum minoris*.

Catenal contacts: In contact landward with thermophilous aspects of karstic deciduous mixed oak woodlands (*Aristolochio luteae-Quercetum pubescentis*).

Synchorology: Karst Lake Doberdò (Friuli Venezia Giulia) (Suppl. material 1, Fig. S1).

Annex I Habitat (92/43/EEC Directive): -

Swamps of the class *Alnetea glutinosae*

Ass.: *GALIO PALUSTRIS-SALICETUM ALBAE* Rauš 1976 (Tab. 4)

Lectotypus hoc loco: rel. 4 of Tab. F4 in Rauš 1976: 53.

Syntaxonomic synonym: *Carici elatae-Salicetum albae* Kevey 2008.

Corresponding names: "Aggr. a *Salix alba*" in Lastrucci et al. (2008); "Facies a *Salix alba* dell'ordine *Alnetalia glutinosae*" in Merloni and Piccoli (2001); *Salicetum albae* Issler 1926 subass. *phragmito-caricetosum* Jurko 1958 var. *Carex elata* in Bolpagni et al. (2007); *Salicetum albae* subass. *phragmito-caricetosum* Jurko 1958 in Šilc (2003).

Diagnostic species: vs *Alnetea glutinosae*: *Salix alba*, *Salix purpurea*; vs *Salicetum albae* s.l. (*Salicion albae*): *Galium palustre* s.l., *Carex elata*.

Structure and composition: Softwood forest with the tree layer dominated by *Salix alba* and the shrub layer poorly developed or absent including besides *S. alba* other willows such as *S. cinerea*, *S. purpurea* and *S. triandra*. The herbaceous layer can be well developed and it includes a large number of marsh elements ingressive from *Phragmito-Magnocaricetea*; common species are *Galium palustre* s.l., *Carex elata*, *Limniris pseudacorus*, *Lysimachia vulgaris* (Rauš 1976; Rauš et al. 1985). Given the wide extension of its distribution area there is a high variability in the floristic composition of the coenosis, affected by dynamic-catenal contacts dependent on territorial characteristics. In the Hungarian territory there is a greater participation of helophytic species (see Tab. 5).

As for Italy (Tab. 4), this community is rather rich in species, with *Salix alba* forming a rather open tree layer, where *Alnus glutinosa* occurs on more developed soils. In the shrub layer, *Salix alba* is often associated with *Frangula alnus*, *Cornus sanguinea*, *Rhamnus cathartica*, *S. cinerea*, *S. purpurea*. The floristic structure of the herbaceous layer is rather variable and similar to that of the Croatian and Hungarian stands: it is usually dominated by tall sedges, namely *Carex elata* and *C. acutiformis*, accompanied by other *Phragmito-Magnocaricetea* elements or by *Rubus ulmifolius* and various other shrubs in more degraded stages.

Syntaxonomy: The syntaxonomic treatment of *Salix alba* swamp woods is still critical: in many studies the hygrophilous woods dominated by the white willow have been designated with the name "*Salicetum albae* Issler 1926", a riverine association described for Central Europe and assigned to the class *Salicetea purpureae*. *Salicetum albae*, however, is both floristically and ecologically different from the *Salix alba* swamp community assignable to the class *Alnetea glutinosae* here reported, which can be attributed on the whole to *Galio palustris-Salicetum albae*, an association described from the Danube River basin in North Eastern Croatia (Rauš 1976) (col. 2 in Tab. 5), and reported also from the Drava and other rivers of that part of Croatia (Rauš 1992; Rauš et al. 1985; Karadžić et al. 2015). *Galio-Salicetum albae* grows in depressions subject to long, frequent, up to 2-4 m high floods, in the swamps and oxbows of the great river systems in the southern Pannonian Plain, on pseudogley or gley soils (Rauš 1976). Rauš (1976) is the first author who distinguished the peculiar features of this white willow swamp at the association level, but he classified it in *Salicion albae*. In spite of the floristic-ecological differences, Šilc (2003) and Vukelić (2012) treated *Galio-Salicetum albae* as a syntaxonomic synonym of *Salicetum albae* Issler 1926.

Yet, Kevey (2008) is the first to recognize in the syntaxonomic classification the particular ecology of the *Salix alba* swamps that he investigated in the Great Hungarian Plain. He attributed these stands to the new association *Carici elatae-Salicetum albae* (col. 1 in Tab. 5), described from the Hungarian side of the River Drava along the border with Croatia, and assigned to *Alnion glutinosae* (*Alnetea glutinosae*).

Table 4. *Galio palustris-Salicetum albae* Rauš 1976 from Italy. Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Complete linkage).

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Area (m²)	90	80	100	100	50	150	100	80	65	80	80	100	100	80	100	100	100	20	-	-	-	-	
No. of species (including sporadic species)	16	17	19	15	18	11	22	23	26	13	13	15	15	14	15	17	14	10	20	16	19	16	Fr.
Diagnostic species of *Galio palustris-Salicetum albae*																							
Salix alba L.	3	4	4	3	4	4	4	4	5	3	3	4	4	4	4	4	4	4	3	2	3	3	100.0
Galium palustre L. s.l. (subsp. *elongatum* (C.Presl) Lange p. max p.)	1	+	1	1	+	+	+	.	.	.	+	.	+	+	+	+	+	+	.	.	.	.	63.6
Carex elata All. subsp. *elata*	3	3	3	3	4	3	4	4	2	2	.	.	4	2	.	.	.	2	.	.	.	.	59.1
Salix purpurea L. s.l.	.	.	1	.	+	.	.	.	.	.	1	1	.	.	3	2	.	.	.	.	1	.	31.8
Diagnostic species of upper units (*Alnion glutinosae*, *Alnetea glutinosae*)																							
Frangula alnus Mill. subsp. *alnus*	.	2	1	1	2	1	1	1	+	2	1	.	+	+	1	+	+	+	1	2	1	.	86.4
Salix cinerea L.	.	.	1	.	.	.	.	.	.	2	2	1	1	1	1	1	1	.	1	+	1	1	59.1
Solanum dulcamara L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	.	+	+	1	31.8
Alnus glutinosa (L.) Gaertn.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	1	1	22.7
Carex vesicaria L.	.	2	+	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	18.2
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	+	.	2	.	+	.	+	.	.	.	.	.	.	18.2
Diagnostic species of *Phragmito-Magnocaricetea*																							
Limniris pseudacorus (L.) Fuss	+	+	1	+	+	+	.	.	.	.	.	.	+	+	.	.	.	1	+	+	+	+	59.1
Lythrum salicaria L.	.	.	+	+	+	+	+	.	.	+	.	1	+	+	+	+	.	.	.	.	+	+	59.1
Lysimachia vulgaris L.	2	2	1	1	1	+	.	+	.	+	.	.	+	.	.	.	+	.	.	.	+	.	50.0
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	.	.	.	1	.	+	3	2	2	.	+	.	.	.	.	+	.	+	.	36.4
Carex acutiformis Ehrh.	.	.	.	.	.	.	.	.	.	.	1	+	1	3	2	1	1	.	.	.	.	.	31.8
Leucojum aestivum L.	1	1	+	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	27.3
Leersia oryzoides (L.) Sw.	.	+	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.6
Phalaris arundinacea L. subsp. *arundinacea*	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	13.6
Mentha aquatica L. subsp. *aquatica*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	13.6
Teucrium scordium L. subsp. *scordium*	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9.1
Diagnostic species of *Rhamno-Prunetea*																							
Cornus sanguinea L. s.l.	.	.	.	.	.	.	1	1	+	1	2	+	2	1	+	2	2	2	1	+	.	.	63.6
Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	2	3	4	3	2	2	36.4
Hedera helix L. subsp. *helix*	.	.	.	.	.	.	.	.	.	.	.	+	.	.	3	2	3	.	1	1	1	2	36.4
Rhamnus cathartica L.	.	.	.	+	+	+	.	.	.	.	.	+	.	.	.	.	.	.	1	1	1	.	31.8
Sambucus nigra L.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.	2	1	1	1	31.8
Prunus spinosa L. subsp. *spinosa*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	1	13.6
Alien species																							
Bidens frondosa L.	3	1	2	2	1	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	31.8
Amorpha fruticosa L.	.	1	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	27.3
Xanthium italicum Moretti	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9.1
Acer negundo L.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	9.1
Parthenocissus quinquefolia (L.) Planch.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9.1
Other species																							
Rubus caesius L.	.	.	.	.	.	.	2	+	1	+	1	1	+	+	1	2	1	.	.	.	+	.	54.5
Convolvulus sepium L.	.	.	.	.	.	.	+	.	1	.	+	1	.	.	.	.	.	.	1	1	1	1	36.4
Urtica dioica L. s.l.	.	.	.	.	.	.	+	+	1	.	.	.	.	.	.	+	.	.	1	.	1	+	31.8
Equisetum arvense L.	.	+	1	1	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	31.8
Eupatorium cannabinum L. subsp. *cannabinum*	.	.	.	.	.	.	.	.	1	+	.	+	.	.	+	+	.	.	+	.	.	.	27.3

Table 4. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Area (m^2)	90	80	100	100	50	150	100	80	65	80	80	100	100	80	100	100	100	20	-	-	-	-	
No. of species (including sporadic species)	16	17	19	15	18	11	22	23	26	13	13	15	15	14	15	17	14	10	20	16	19	16	Fr.
Populus alba L. (incl. *P. canescens* (Aiton) Sm.)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	+	1	1	22.7
Lysimachia nummularia L.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	1	1	+	.	.	.	.	.	22.7
Potentilla reptans L.	2	.	.	.	.	.	+	+	2	.	.	.	.	.	+	.	.	.	.	.	.	.	18.2
Clematis viticella L.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	18.2
Mentha arvensis L.	.	+	2	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18.2
Thalictrum lucidum L.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18.2

However, *Carici-Salicetum* is both floristically and ecologically very similar to *Galio-Salicetum*. The two associations share in addition almost the same distribution; furthermore, they are both reported respectively by Rauš (1992) and Kevey (2008, 2019) from the same sector of the River Drava along the Croatian-Hungarian border, where incidentally the holotype of *Carici-Salicetum* is located and that is close to the Danube stretch from which *Galio-Salicetum* was described. In our opinion *Galio-Salicetum* and *Carici-Salicetum* may correspond to the same forest type found within the same fluvial systems. As a matter of fact, the floristic analysis of the synoptic table (Tab. 5) clearly suggests that *Carici-Salicetum*, *Galio-Salicetum* and the Italian relevès should be referred to the same association, but the name *Galio-Salicetum* has the priority; this way, the Kevey's (2008) name must be considered as a syntaxonomic synonym. *Carici-Salicetum* seems to include stands associated to long-lasting stagnant water, characterized by a good expression of helophytic elements of *Phragmito-Magnocaricetea*, which can be considered as the most hygrophilous term of the association, opposed to stands rich in *Rubus ulmifolius* found in Italy and discussed hereafter.

The ecological features of *Galio-Salicetum* support the interpretation of Kevey (2008) and the association is therefore here referred to *Alnetea glutinosae*. Therefore, *Galio-Salicetum* represents the swamp counterpart of the riverside *Salix alba* woods belonging to the riparian alliance *Salicion albae* (*Salicetea purpureae*). *Salicetum albae* Issler 1926 (cols. 4-7 in Tab. 5) is distinguished from these white willow swamps by the lack of its own differential species, the lower participation of ingressive elements of *Phragmito-Magnocaricetea* and a quantitative variation of some elements such as *Phalaris arundinacea* and *Urtica dioica*, much better represented than in *Galio-Salicetum*; its floristic composition is influenced by catenal contacts leading to a good expression of *Alno-Populetea* and *Rhamno-Prunetea* elements.

Salix alba stands related to lentic habitats are reported from various areas of northern and central Italy (Tab. 4, col. 3 in Tab. 5). In Italy, white willow swamp vegetation had not been considered so far as an autonomous unit: the first author who realized the ecological difference of white willow woods of lentic habitats was Pirola (1968), who described the establishment of *Salix alba* woods on *Magnocaricion* communities in the oxbow lakes of the River Ticino, but their syntaxonomic treatment was not subsequently addressed. This woodland type probably corresponds to the white willow stands observed by Pedrotti (1988) at Lake Loppio, for which unfortunately no relevés are available. Also the stands with *Salix alba* and *Carex elata* reported by Tisi et al. (2007) from the banks of the lakes of the area "Cinque Laghi" of Ivrea, Piedmont region (SAC IT 1110021) could be attributed to this association: indeed, these coenoses are sometimes interpreted in the literature as dynamic stages of helophytic communities with *S. alba*.

A synoptic table of the association in Europe is provided in Tab. 5.

Synecology: *Galio-Salicetum* is found along the banks of lowland lentic habitats with stagnant or very slow-flowing water, in frequently and long-flooded sites with prevalent vertical water movements and high water table, in shallow depressions, backwaters, oxbow lakes and lentic channels in connection with great river systems and lacustrine/palustrine habitats; it grows on waterlogged hydromorphic soils with a great content of slightly decomposed organic matter, even moderately peaty; however peat accumulation is more limited than in other swamp forests (Kevey 2019).

In Italy, *Galio-Salicetum albae* is found along the banks of lakes and minor water bodies, on alluvial and colluvial, muddy, fine-textured, hydromorphic soils with a good content of organic matter. The Italian stands show a certain variability, and three main aspects of the coenosis can be distinguished, mainly related to different flooding and soil moisture conditions. The *Carex elata*-rich stands (rels. 1-9, Tab. 4) correspond to a definitely hygrophilous vegetation growing on frequently flooded soils enriched with organic matter (hydromor); *Carex acutiformis*-rich stands (rels. 10-17) represent a dynamic stage of shrub encroachment and eutrophication, differentiated by this large sedge and with a lesser expression of *C. elata*, mostly found in abandoned quarry pits and other artificial water bodies; finally the stands enriched in *Rubus ulmifolius*, accompanied by other woody species (rels. 18-22) are the most termophilous and the least hygrophilous ones corresponding to a more advanced stage of shrub encroachment.

Dynamic contacts: The association can be considered as a permanent community being the final product of a dynamic evolution of *Magnocaricion* communities driven by infilling processes, as realized by Pirola (1968).

Catenal contacts: It comes in contact with aquatic communities (*Lemnetea*, *Potametea*), helophytic and hygro-nitrophilous herbaceous vegetation (*Phragmito-Magnocaricetea*, *Bidentetea tripartitae* and *Agrostietea stoloniferae*), and shrub communities (mainly *Frangulo-Salicetum cinereae*, which may be locally considered its functional mantle).

Synchorology: Croatia and Hungary (area of the Danube, Drava, Sava, Tisza rivers in the Pannonian Plain), Slovenia and Italy. In Italy it is recorded from Friuli Venezia Giulia, Veneto, Lombardy, Emilia-Romagna, Tuscany (Suppl. material 1, Fig. S1); probably it also occurs in Trentino and Piedmont.

Annex I Habitat (92/43/EEC Directive): this *Salix alba* swamp woodland can be attributed to habitat 91E0*. Therefore, it is suggested to integrate *Galio palustris-Salicetum albae* in the vegetation types included in this Natura 2000 forest habitat.

Riparian, alluvial and karstic lakeshore meso-hygrophilous forests of the class *Alno-Populetea*

Ass.: *DIOSCOREO COMMUNIS-POPULETUM NIGRAE* Poldini & Vidali in Poldini, Sburlino & Vidali 2017 (Tab. 6)

Pseudonyms: *Salici-Populetum nigrae* sensu Auct. Ital. p.p. non Meijer Drees 1936.

TYPICUM subass. nov. (*typus* of the subassociation: the *holotypus* of the association: rel. 1 of Table I of Poldini & Vidali in Poldini, Sburlino & Vidali 2017: 1113, corresponding to rel. 8 of Tab. 6 in this paper)

VAR. *ALNUS INCANA* (rels. 21-23 of Tab. 6 in this paper)

POPULETOSUM ALBAE (Biondi, Vagge, Baldoni & Taffetani 1999) Poldini, Vidali & Castello *comb. nov*.

Basionym: *Salici-Populetum nigrae populetosum albae* Biondi, Vagge, Baldoni & Taffetani 1999.

Holotypus: rel. 6 of Tab. 16 in Biondi et al. 1999: 78, corresponding to rel. 7 of Tab. 6 in this paper.

VAR. *LIGUSTRUM VULGARE* (rels. 1-3 of Tab. 6 in this paper)

Diagnostic species: *Dioscorea communis*, *Corylus avellana*, *Robinia pseudoacacia*, *Juglans regia*, *Parietaria officinalis*, *Aegopodium podagraria* (Poldini et al. 2017).

Structure and composition: Riverine woods dominated by *Populus nigra* (including hybrids), with a high frequency of *Salix alba*, accompanied by different tree species such as *Robinia pseudoacacia* and *Ulmus minor*; *Populus alba* can be generally found in higher sites. The shrub layer is rather developed and rich in species, many of which belonging to *Rhamno-Prunetea*. Lianas are characteristically well represented; common species are *Dioscorea communis*, *Hedera helix*, *Clematis vitalba*. The herbaceous layer is rather poorly developed and discontinuous: common species are *Brachypodium sylvaticum*, *Aegopodium podagraria*, *Parietaria officinalis*, and there are many hygro-nitrophilous species. Various alien species may occur such as *Robinia pseudoacacia*, *Amorpha fruticosa*, *Solidago gigantea*, *Buddleja davidii*, *Reynoutria* spp.

Syntaxonomy: The *Dioscoreo-Populetum nigrae* association recently described by Poldini et al. (2017) is here reconsidered adding relevés related to the most external Holocene river terraces and some impoverished aspects occurring on river islands and elevated lateral gravel bars of the great Alpine rivers, in particular of the braided section of the River Tagliamento. The relevés along the River Po published by Tomaselli (1959) were not considered due to their extreme floristic impoverishment; the author himself suggests that they are heavily human-degraded stands.

Synecology: *Dioscoreo-Populetum* is a riparian woodland that thrives mainly in the middle and lower reaches of rivers. It is found on sandy-gravelly to sandy-silty mineral calcareous, excessively drained soils. It grows in sites with high water table on recent terraces and their scarps reaching the upper parts of the floodplain, and also on river islands in the active channel of gravel-bed rivers with torrential character of the Po Plain; moreover it can

Table 5. Simplified synoptic table of *Galio palustris-Salicetum albae* Rauš 1976 and *Salicetum albae* Issler 1926 *typicum.* 1: Hungary (Kevey 2008); 2: Croatia (Rauš 1976); 3: Italy (Tab. 4 in this paper); 4: Slovenia (Šilc 2003); 5 - 7: Germany (Oberdorfer 1992).

Number of column	1	2	3	4	5	6	7
Number of relevés	20	10	22	9	141	47	6
	Galio palustris-Salicetum albae			***Salicetum albae typicum***			
Limniris pseudacorus (L.) Fuss	**100.0**	**90.0**	**59.1**	22.0	5.0	9.0	50.0
Lysimachia vulgaris L.	**80.0**	**50.0**	**50.0**	11.0	4.0	11.0	17.0
Phragmites australis (Cav.) Trin. ex Steud. s.l.	**95.0**	.	**36.4**	11.0	16.0	23.0	.
Galium palustre L. s.l. (subsp. *elongatum* (C.Presl) Lange p. max p.)	**100.0**	**90.0**	**63.6**	22.0	4.0	.	.
Lycopus europaeus L.	**100.0**	**20.0**	**18.2**	.	11.0	.	.
Mentha aquatica L. subsp. *aquatica*	**65.0**	**10.0**	**13.6**	22.0	.	.	.
Carex elata All. subsp. *elata*	**75.0**	**90.0**	**59.1**	.	.	.	.
Scutellaria galericulata L.	**70.0**	**30.0**	**9.1**	.	.	.	.
Bidens tripartita L. s.l.	**60.0**	**30.0**	**4.5**	.	.	.	.
Carex vesicaria L.	**60.0**	**20.0**	**18.2**	.	.	.	.
Salix cinerea L.	**35.0**	.	**59.1**	.	.	.	.
Frangula alnus Mill. subsp. *alnus*	**10.0**	.	**86.4**	.	.	.	.
Alnus glutinosa (L.) Gaertn.	**15.0**	.	**22.7**	.	8.0	2.0	.
Sium latifolium L.	**100.0**	**10.0**	.	.	.	.	.
Rorippa amphibia (L.) Besser	**75.0**	**10.0**	.	.	.	.	.
Myosotis scorpioides L.	**55.0**	**30.0**	.	.	14.0	6.0	.
Rumex hydrolapathum Huds.	**40.0**	**30.0**	.	.	.	.	.
Leucojum aestivum L.	.	**10.0**	**27.3**	.	.	.	.
Galium aparine L.	55.0	.	.	**44.0**	**63.0**	**51.0**	**67.0**
Sambucus nigra L.	10.0	.	31.8	**67.0**	**57.0**	**45.0**	**17.0**
Salix purpurea L. s.l.	.	.	31.8	**22.0**	**34.0**	**45.0**	**17.0**
Glechoma hederacea L.	10.0	.	9.1	**89.0**	**46.0**	**30.0**	**33.0**
Lamium maculatum L.	.	.	.	**78.0**	**45.0**	**34.0**	**17.0**
Angelica sylvestris L. subsp. *sylvestris*	10.0	.	.	**67.0**	**53.0**	**62.0**	**50.0**
Anthriscus sylvestris (L.) Hoffm. subsp. *sylvestris*	.	.	.	**67.0**	**16.0**	**21.0**	**33.0**
Aegopodium podagraria L.	.	.	.	**44.0**	**36.0**	**40.0**	**67.0**
Cirsium oleraceum (L.) Scop.	.	.	.	**22.0**	**35.0**	**28.0**	**67.0**
Alliaria petiolata (M.Bieb.) Cavara & Grande	.	.	.	**56.0**	**35.0**	**13.0**	.
Salix triandra L. subsp. *triandra*	.	10.0	.	**44.0**	**14.0**	**4.0**	.
Salix ×fragilis L.	.	.	.	**33.0**	**26.0**	**19.0**	.
Galeopsis speciosa Mill.	.	.	.	**44.0**	.	**6.0**	**17.0**
Artemisia vulgaris L.	.	.	.	**44.0**	**14.0**	.	.
Impatiens noli-tangere L.	25.0	10.0	.	.	**52.0**	**34.0**	.
Prunus padus L.	.	.	.	.	**48.0**	**45.0**	.
Alnus incana (L.) Moench	.	.	.	.	**26.0**	**60.0**	.
Impatiens parviflora DC.	.	.	.	.	**43.0**	**4.0**	**67.0**
Populus nigra L. (incl. *P. ×canadensis* Moench)	.	.	9.1	.	**41.0**	**30.0**	**33.0**
Lolium giganteum (L.) Darbysh.	.	15.0	.	.	**36.0**	**30.0**	**17.0**
Stachys sylvatica L.	.	.	.	.	**31.0**	**19.0**	**33.0**
Deschampsia cespitosa (L.) P.Beauv. s.l.	.	.	.	.	**23.0**	**49.0**	**33.0**
Brachypodium sylvaticum (Huds.) P.Beauv.	.	.	.	.	**20.0**	**32.0**	**50.0**
Fraxinus excelsior L. subsp. *excelsior*	.	.	.	.	**18.0**	**28.0**	**67.0**
Filipendula ulmaria (L.) Maxim.	.	.	.	.	**13.0**	**13.0**	**67.0**
Lonicera xylosteum L.	.	.	.	.	**12.0**	**23.0**	**67.0**
Eupatorium cannabinum L. subsp. *cannabinum*	.	.	.	.	**11.0**	**15.0**	**67.0**
Other species							
Salix alba L.	100.0	100.0	100.0	100.0	97.0	100.0	100.0
Symphytum officinale L.	100.0	30.0	13.6	11.0	36.0	47.0	83.0
Urtica dioica L. s.l.	75.0	40.0	31.8	100.0	89.0	79.0	100.0
Humulus lupulus L.	35.0	20.0	13.6	22.0	45.0	51.0	17.0
Rubus caesius L.	65.0	70.0	54.5	.	81.0	74.0	83.0
Lysimachia nummularia L.	60.0	50.0	.	11.0	11.0	19.0	33.0
Poa trivialis L.	95.0	.	13.6	67.0	48.0	17.0	33.0
Phalaris arundinacea L. s.l.	70.0	.	13.6	100.0	73.0	81.0	83.0
Cornus sanguinea L. s.l.	55.0	.	63.6	11.0	73.0	47.0	83.0
Solanum dulcamara L.	100.0	30.0	31.8	67.0	18.0	9.0	.
Lythrum salicaria L.	85.0	40.0	59.1	56.0	1.0	6.0	.
Ranunculus repens L.	50.0	30.0	13.6	22.0	21.0	4.0	.
Convolvulus sepium L	35.0	20.0	36.4	67.0	26.0	30.0	.
Stachys palustris L.	65.0	20.0	13.6	.	1.0	6.0	.
Stellaria aquatica (L.) Scop.	50.0	10.0	4.5	.	20.0	11.0	.

Table 5. Continuation.

Number of column	1	2	3	4	5	6	7
Number of relevés	20	10	22	9	141	47	6
	Galio palustris-Salicetum albae			*Salicetum albae typicum*			
Persicaria hydropiper (L.) Delarbre	10.0	60.0	4.5	33.0	.	.	.
Agrostis stolonifera L. subsp. *stolonifera*	.	70.0	4.5	33.0	5.0	4.0	.
Rhamnus cathartica L.	.	.	31.8	33.0	.	2.0	17.0
Carex acutiformis Ehrh.	.	.	31.8	.	6.0	47.0	33.0
Euonymus europaeus L.	.	.	13.6	44.0	18.0	28.0	33.0
Crataegus monogyna Jacq.	5.0	.	9.1	.	.	4.0	33.0

reach the external ancient river terraces with peculiar xerophilous aspects. Compared to willow woodland (*Amorpho-Salicetum albae*) it typically thrives in upper sites which are still prone to flooding during normal high discharge, but are less frequently or occasionally inundated.

On the basis of the present analysis, *Dioscoreo-Populetum* has been divided into two subunits: the subassociations *typicum* and *populetosum albae* (Tab. 6).

The subass. *populetosum albae* (rels. 1-7 in Tab. 6) was described by Biondi et al. (1999) for *Populus nigra* and *Salix alba* woodland designated as *Salici-Populetum* from the River Stirone and is characterized by the dominance of *Populus alba*. Similar stands are here reported from the lower reaches of the River Tagliamento, on higher river terraces subject to less frequent and shorter floods than the typical subass. A particular aspect was observed on the most external old Holocene river terraces, which have been almost completely destroyed by agriculture activity: along the Tagliamento it has been possible to identify a vegetation richer in *Rhamno-Prunetea* shrubs and *Acer campestre*, with an impoverishment of both riparian (*Salix alba*) and gravel banks (*S. purpurea*, *S. eleagnos*) willows, a reduction of *Robinia pseudoacacia* and absence of *Sambucus nigra*. It is here described as a variant with *Ligustrum vulgare* and *Fraxinus ornus* (rels. 1-3), which is (potentially) related to middle and lower river reaches.

The subass. *typicum* (rels. 8-23) grows on recent terraces and their scarps towards the floodplain, more internally than the subass. *populetosum albae*. It encompasses most of the relevés published by Poldini et al. (2017) and corresponds to the most typical riparian vegetation, in which willows are more common; it has no differential species. A group of relevés with Apennine origin (rels. 10-13), is distinguished by a more thermophilous character (*Viola alba* subsp. *dehnhardtii*), abundant *Robinia pseudoacacia* and elements such as *Prunus spinosa*, *P. avium* indicating more developed soils. Within the typical subassociation, two aspects can be distinguished.

An aspect is represented by the stands with *Populus nigra* and *Salix eleagnos* observed in the braided sections of the middle course of the River Tagliamento between Osoppo and Morsano al Tagliamento (rels. 14-20), on river islands (braid bars) and also on high lateral bars (c. a few meters elevated with respect to the river bed) in the active channel, on sandy-silty soil deposited by less frequent floods. In braided river reaches, the formation of vegetated islands is greatly supported by a natural flood regime, a sufficient source of sediments, an unconstrained channel and large woody debris: tree trunks and branches promote the subsequent accumulation of coarse sediments, the establishment of pioneer fast-growing woody species able to resprout such as willows and poplars, and the increasing stability of river islands, where seeds can germinate (see Tockner et al. 2003). Here the community occurs with a more primitive aspect and a tall-shrub structure: it is still dominated by *Populus nigra* accompanied by river bed willows of *Salicetea purpureae*, but it is negatively characterized by the considerable reduction of *Rhamno-Prunetea* (*Berberidion*) elements, due to the lower development of soils and higher exposure to hydrodynamics and river erosion.

A variant with *Alnus incana* accompanied by *Ostrya carpinifolia* includes the lowland stands of the Alpine foreland, located in the transition area between the upper and the middle course of the River Tagliamento (around Osoppo Field, or "Piana di Osoppo") (rels. 21-23). This area of the High Plain is still influenced by the inflows of elements from the prealpine, colline-submontane grey alder riparian woods of *Primulo vulgaris-Alnetum incanae*: here *Populus nigra* can get mixed with *Alnus incana*.

Synchorology: North-Eastern and Central Po Plain (Friuli Venezia Giulia, Veneto, Emilia Romagna), from upper mesotemperate to lower supratemperate horizons in the Temperate oceanic and continental bioclimates.

Annex I Habitat (92/43/EEC Directive): 92A0. Submediterranean riverside woodlands rich in *Populus* spp. of the alliance *Dioscoreo-Populion* found in the Po Plain should be included in this habitat.

All.: *DIOSCOREO COMMUNIS-ULMION MINORIS* Poldini & Vidali in Poldini, Sburlino & Vidali 2017

This alliance has recently been introduced by Poldini et al. (2017) to include meso-hygrophilous, riverine *Ulmus minor*-rich woods that grow on upper river terraces in the North-Eastern and Central Po Plain.

In light of the new alliance, a survey of the hardwood forests rich in *Ulmus minor* found along the river systems of the Po Plain was carried out in order to verify their syntaxonomic treatment and their possible inclusion into *Dioscoreo-Ulmion*. Indeed, the survey considered Po Plain mesophilous and meso-hygrophilous *Ulmus minor*-rich communities, which were originally at-

Table 6. *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini, Sburlino & Vidali 2017, *populetosum albae* (Biondi, Vagge, Baldoni & Taffetani 1999) Poldini, Vidali & Castello *comb. nov.* (rels.1-7), *typicum subass. nov.* (rels. 8-23). Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Complete linkage).

Relevé number	1	2	3	4	5	6	7**	8*	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Altitude (m a.s.l.)	15	80	145	5	5	-	-	-	70	-	-	-	-	190	3	-	10	73	20	13	170	205	230	
No. of species (incl. sporadic species)	31	28	26	31	34	18	24	43	29	27	21	36	37	21	29	22	17	20	29	33	27	22	22	Fr.
	populetosum albae							*typicum*																
	var. *Ligustrum vulgare* ancient terraces of middle and lower reaches			river terraces				recent terraces of middle and lower reaches						river islands of middle and lower reaches							var. *Alnus incana* prealpine recent terraces			
Diagnostic species of *Dioscoreo-Populetum nigrae* and *Dioscoreo-Populion nigrae*																								
Dioscorea communis (L.) Caddik et Wilkin	+	2	+	1	1	+	1	1	1	+	+	+	+	.	.	.	+	.	.	.	.	.	+	65.2
Corylus avellana L.	1	+	.	+	+	.	2	+	2	+	.	+	+	+	+	+	+	.	.	.	.	.	.	60.9
Robinia pseudoacacia L.	+	1	.	1	1	1	2	.	1	**4**	**4**	**2**	**2**	.	.	+	.	.	+	.	.	.	+	60.9
Juglans regia L.	.	1	.	.	.	+	1	.	.	+	+	+	+	.	+	+	.	.	.	.	.	+	.	43.5
Parietaria officinalis L.	.	.	.	.	.	+	1	+	.	2	.	+	+	.	1	+	.	.	.	.	.	.	.	34.8
Aegopodium podagraria L.	.	.	.	.	.	.	2	+	.	1	.	+	+	.	2	.	.	.	+	2	.	.	.	34.8
Species of subass. *populetosum albae*																								
Populus alba L. (incl. *P. canescens* (Aiton) Sm.)	**3**	**3**	**2**	**2**	**2**	**4**	**4**	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	34.8
Species of *Ligustrum vulgare* var.																								
Ligustrum vulgare L.	**3**	**2**	**2**	1	1	.	.	2	+	.	.	.	1	+	.	.	.	.	.	.	1	+	1	52.2
Fraxinus ornus L. subsp. *ornus*	**1**	**1**	**1**	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	1	1	.	30.4
Species of thermophilous aspect																								
Equisetum ramosissimum Desf.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	17.4
Viola alba Besser subsp. *dehnhardtii* (Ten.) W. Becker	.	.	.	.	.	.	.	.	.	**1**	**1**	**1**	**1**	.	.	.	.	.	.	.	.	.	.	17.4
Prunus avium (L.) L.	.	.	.	.	.	.	3	.	.	+	**1**	**1**	+	.	.	.	.	.	.	.	.	.	.	21.7
Quercus petraea (Matt.) Liebl.	.	.	r	.	.	.	1	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	21.7
Prunus spinosa L. subsp. *spinosa*	.	.	.	.	.	.	1	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	17.4
Species of *Alnus incana* var.																								
Alnus incana (L.) Moench	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	**1**	13.0
Carex alba Scop.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	**2**	+	+	17.4
Molinia arundinacea Schrank	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**2**	**2**	**1**	13.0
Ostrya carpinifolia Scop.	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	+	21.7
Species of *Populetalia albae* and *Alno glutinosae-Populetea albae*																								
Rubus caesius L.	2	2	.	2	2	3	2	3	2	2	4	4	4	3	2	2	3	3	+	3	2	2	2	95.7
Populus nigra L. (incl. *P. xcanadensis* Moench)	.	1	1	1	1	3	2	3	2	2	4	4	4	4	4	4	4	2	3	2	3	4	4	95.7
Brachypodium sylvaticum (Huds.) P. Beauv.	+	1	2	2	2	.	1	1	.	+	1	1	2	4	2	4	1	+	+	1	1	3	3	91.3
Ulmus minor Mill. subsp. *minor*	1	2	+	3	3	1	+	1	1	.	.	.	.	.	.	+	.	1	.	.	+	.	.	52.2
Sambucus nigra L.	.	.	.	+	+	.	1	2	2	3	.	+	1	.	2	1	.	.	+	1	.	.	.	52.2
Clematis vitalba L.	.	.	.	.	.	.	.	1	.	1	1	+	+	+	.	.	+	.	.	+	.	+	1	43.5
Humulus lupulus L.	.	.	.	.	1	.	.	.	.	+	.	.	+	.	1	2	+	+	.	+	.	.	.	34.8
Carex pendula Huds.	.	.	.	.	.	2	1	.	.	.	.	+	+	.	2	+	.	+	.	.	.	.	.	30.4
Convolvulus sepium L.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	+	.	.	+	+	.	+	.	30.4
Equisetum hyemale L.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	21.7
Urtica dioica L. s.l.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	2	.	.	+	+	.	.	.	21.7

Table 6. Continuation.

Relevé number	1	2	3	4	5	6	7**	8*	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Altitude (m a.s.l.)	15	80	145	5	5	-	-	-	70	-	-	-	-	190	3	-	10	73	20	13	170	205	230	
No. of species (incl. sporadic species)	31	28	26	31	34	18	24	43	29	27	21	36	37	21	29	22	17	20	29	33	27	22	22	Fr.
	populetosum albae							***typicum***																
	var. *Ligustrum vulgare* ancient terraces of middle and lower reaches			**river terraces**				**recent terraces of middle and lower reaches**						**river islands of middle and lower reaches**							**var. *Alnus incana* prealpine recent terraces**			
Carex remota L.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	1	.	.	.	.	.	.	.	.	17.4
Alliaria petiolata (M. Bieb.) Cavara et Grande	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	+	r	.	.	.	17.4
Alnus glutinosa (L.) Gaertn.	1	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.0
Clematis viticella L.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.0
Heracleum sphondylium L. s.l.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	13.0
Saponaria officinalis L.	.	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	13.0
Galium aparine L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	13.0
Ficaria verna Huds. s.l.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	8.7
Geum urbanum L.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	8.7
Glechoma hederacea L.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	8.7
Species of *Salicetea purpureae*																								
Salix alba L. (incl. *S. ×fragilis* L.)	.	1	.	1	1	3	.	2	2	+	1	2	1	3	1	2	.	+	.	3	1	.	.	69.6
Salix eleagnos Scop.	.	.	.	.	.	1	.	.	.	.	.	1	2	.	.	.	+	+	2	+	+	2	.	39.1
Salix purpurea L. s.l.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	.	.	.	21.7
Salix daphnoides Vill.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	4.3
Species of *Alnetea glutinosae*																								
Frangula alnus Mill. subsp. *alnus*	.	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	21.7
Salix cinerea L.	.	.	.	+	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.0
Phragmites australis (Cav.) Steud. subsp. *australis*	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	13.0
Lycopus europaeus L.	.	.	.	1	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	17.4
Species of *Rhamno-Prunetea*																								
Cornus sanguinea L. subsp. *hungarica* (Kárpáti) Soó	+	2	1	1	1	1	2	2	3	2	2	2	2	1	.	+	+	.	.	+	1	1	1	87.0
Hedera helix L. subsp. *helix*	3	3	+	+	+	.	4	3	1	2	1	1	+	+	1	.	+	+	.	+	1	.	1	82.6
Crataegus monogyna Jacq.	2	2	+	1	1	+	2	.	.	1	+	+	+	+	.	.	.	+	.	.	+	+	.	65.2
Acer campestre L.	2	2	+	+	+	.	.	1	1	.	+	+	+	.	.	.	.	.	.	+	.	.	.	47.8
Lonicera caprifolium L.	1	+	.	+	+	.	.	+	1	+	.	.	.	2	.	.	+	.	.	.	.	.	.	39.1
Euonymus europaeus L.	.	+	.	1	1	1	2	+	.	1	+	.	+	.	.	.	.	.	.	.	.	.	.	39.1
Rhamnus cathartica L.	+	1	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	17.4
Other species																								
Amorpha fruticosa L.	.	.	+	.	.	1	.	.	.	.	.	2	2	+	.	.	1	4	+	1	+	+	.	47.8
Solidago gigantea Aiton	.	.	.	+	+	.	.	+	.	.	.	1	+	.	.	.	+	.	+	+	.	+	+	43.5
Viola reichenbachiana Jord. ex Boreau (incl. *V. riviniana* Rchb. subsp. *riviniana*)	1	+	.	.	.	.	.	+	1	.	.	+	+	.	.	.	.	.	.	.	+	.	+	34.8
Platanus hispanica Mill. ex Münchh.	1	1	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	17.4
Primula vulgaris Huds. subsp. *vulgaris*	.	1	.	.	.	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17.4
Clematis recta L.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.0
Lonicera xylosteum L.	+	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	13.0

Table 6. Continuation.

Relevé number	1	2	3	4	5	6	7**	8*	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Altitude (m a.s.l.)	15	80	145	5	5	-	-	-	70	-	-	-	-	190	3	-	10	73	20	13	170	205	230	
No. of species (incl. sporadic species)	31	28	26	31	34	18	24	43	29	27	21	36	37	21	29	22	17	20	29	33	27	22	22	Fr.
	populetosum albae							***typicum***																
	var. *Ligustrum vulgare* ancient terraces of middle and lower reaches			**river terraces**				**recent terraces of middle and lower reaches**						**river islands of middle and lower reaches**							**var. *Alnus incana* prealpine recent terraces**			
Salvia glutinosa L.	.	1	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.0
Poa sylvicola Guss.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	13.0
Dactylis glomerata L.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	13.0
Fraxinus excelsior L. subsp. *excelsior*	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	13.0
Symphytum officinale L.	.	.	.	+	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13.0
Galium mollugo L.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	13.0
Phalaris arundinacea L. subsp. *arundinacea*	.	.	.	+	+	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.	.	.	.	21.7
Equisetum arvense L.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	13.0
Agrostis stolonifera L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	+	1	.	17.4
Buddleja davidii Franch.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	13.0
Helianthus tuberosus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	3	.	.	+	13.0

tributed to *Alno-Padion* Knapp 1942 (syn.: *Alno-Ulmion*, *Fraxino-Carpinion*), currently regarded as a synonym of *Alnion incanae* (see Biondi et al. 2015; Biondi and Blasi 2015; Mucina et al. 2016); however, the occurrence of the critical *Alnion incanae* alliance (and in particular of the *Ulmenion* suballiance) in the lowland areas of the Po Plain has to be reconsidered in light of Biondi et al. (2015) and Mucina et al. (2016).

The analysis mainly took into account the synthesis of riparian and swamp forests of Italy of Pedrotti and Gafta (1996), and was based on published relevés of woods with elm, oak, ash and white poplar from the central-western Po Plain area assigned in the literature to *Alno-Padion*, taken from Cavani et al. (1981), Sartori and Zucchi (1981), Bracco et al. (1984), Sartori (1984), Guglielmetto Mugion and Montacchini (1993-94), Assini (1998, 2011a). Furthermore, unpublished relevés of *Ulmus minor* lakeshore forest stands from the Karst were considered. These *Ulmus minor*-rich stands were compared to the analogous Po Plain riverine and alluvial plain forest types already described as *Lamio-Ulmetum* (the type of the *Dioscoreo-Ulmion* alliance) from Poldini et al. (2017), *Asparago-Quercetum roboris* (*Erythronio-Carpinion*) from Lausi (1967), *Rubo caesii-Ulmetum minoris* (*Carici remotae-Fraxinion oxycarpae*) from Corbetta and Censoni Zanotti (1974, sub "*Carici-Fraxinetum angustifoliae* Pedrotti 1970"), as well as *Dioscoreo-Populetum* (*Dioscoreo-Populion*) from the original table in Poldini et al. (2017).

The cluster analysis of the relevés (Fig. 1) highlights 3 main clusters that are well connected to ecological differences of the stands.

Cluster 1 includes the mesophilous oak-hornbeam stands occurring in the low Po Plain on deep alluvial soils with high water table, namely *Asparago-Quercetum* from the eastern Po Plain (group A) and *Polygonato-Quercetum* (group B) from the central-western Po Plain. The relevés of these two forest types are clearly separated, confirming their autonomy basically related to distinctive biogeographical features that lead to their assignment to different alliances.

Cluster 2 includes the stands of meso-hygrophilous forests from the Po Plain rivers and the Karst lakes. The relevés of *Lamio-Ulmetum*, *Rubo-Ulmetum* and *Dioscoreo-Populetum* are clearly distinguished as three different groups (D, G, F respectively). The dendrogram allows the identification of three other main groups of elm-rich stands: groups C and H include riparian forests from the western Po Plain that are described in this paper as the new associations *Vinco minoris-Ulmetum minoris* and *Salvio glutinosae-Quercetum roboris*; group E encompasses the woods from the Karst lakes attributed to the new association *Rhamno catharticae-Ulmetum minoris*. The PCA of the relevés of this cluster (Fig. 2) shows a remarkable separation of *Rubo-Ulmetum* from the other stands. This is a forest type with *Ulmus minor*, *Quercus robur* and *Fraxinus angustifolia* subsp. *oxycarpa* reported from a wide loop of the River Reno (Romagna) (Corbetta and Censoni Zanotti 1974; Brullo and Spampinato 1999): the

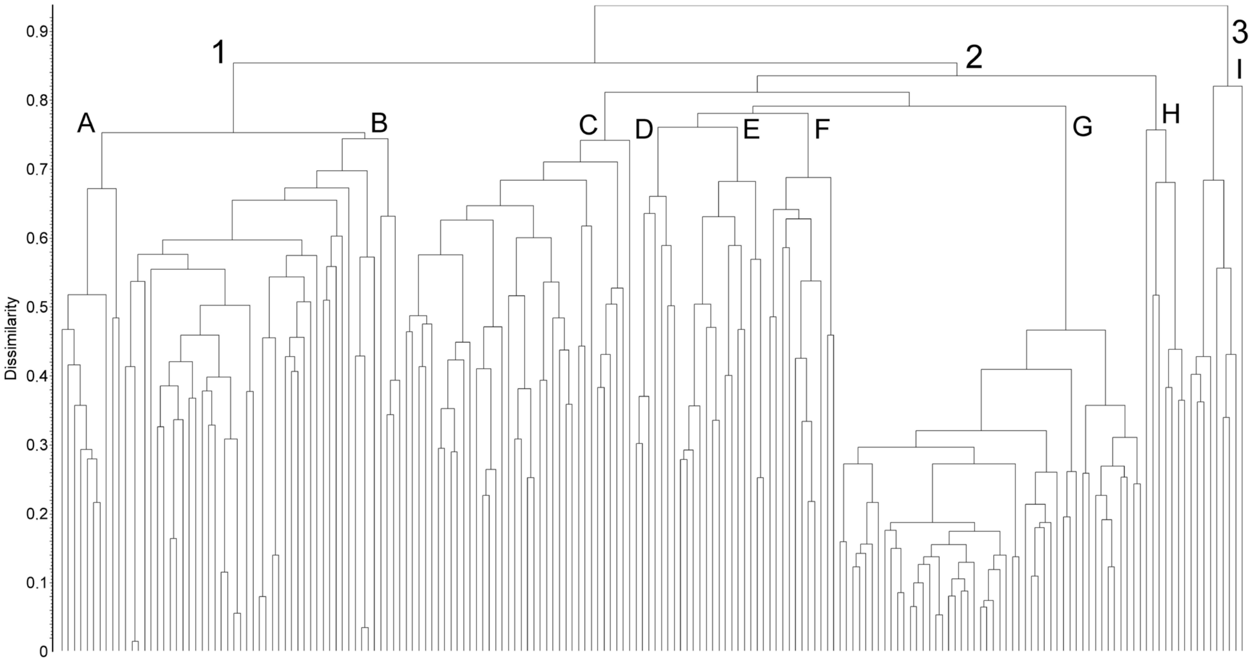

Figure 1. Cluster analysis (cover data, Similarity ratio, WPGMA) of alluvial/waterside woods rich in *Ulmus minor* from the central-western Po Plain assigned in the literature to *Alno-Padion* and from the Karst area, riverine woods of *Lamio-Ulmetum* and *Dioscoreo-Populetum*, alluvial oak-hornbeam woods of *Asparago-Quercetum roboris* of the central-eastern Po Plain. Numbering of objects is omitted. A: *Asparago-Quercetum roboris* (from Lausi 1967); B: *Polygonato-Quercetum roboris* (Sartori 1984; Assini 2011a); C: *Vinco minoris-Ulmetum minoris ass. nov*. (Tab. 2 in Sartori and Zucchi 1981, sub "Boschetti di Olmo e Farnia"; Tab. 2 in Cavani et al. 1981, sub "Querceto misto a *Quercus robur* e *Ulmus minor*"; Tab. XXI in Bracco et al. 1984, sub *Polygonato multiflori-Quercetum roboris*; Tab. 10 in Assini 1998, sub *Querco-Ulmetum minoris*; see Tab. 9 in this paper); D: *Lamio-Ulmetum minoris* (Poldini et al. 2017); E: *Rhamno catharticae-Ulmetum minoris ass. nov*. (Tab. 8 in this paper); F: *Dioscoreo-Populetum* (Poldini et al. 2017); G: *Rubo caesii-Ulmetum minoris* (Corbetta and Censoni Zanotti 1974); H: *Salvio glutinosae-Quercetum roboris ass. nov*. (Tab. 1, rels. 1-7 in Cavani et al. 1981, sub "Boschi igrofili a *Populus alba*"; see text); I: "*Querco-Ulmetum minoris*" (Tab. VI in Guglielmetto Mugion and Montacchini 1993-94).

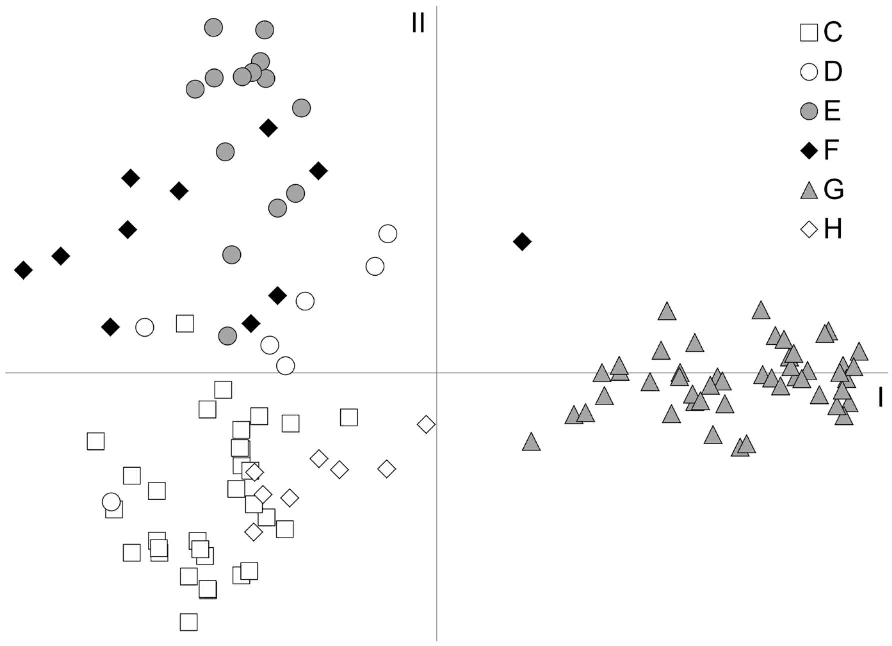

Figure 2. PCA of the relevés of cluster 2 of the dendrogram of Fig. 1 (First component: 20.34 % of total variance, second component: 10.76 %). Relevés are grouped and labelled according to the dendrogram of Fig. 1. C: *Vinco minoris-Ulmetum minoris ass. nov*.; D: *Lamio-Ulmetum minoris*; E: *Rhamno catharticae-Ulmetum minoris ass. nov*.; F: *Dioscoreo-Populetum*; G: *Rubo caesii-Ulmetum minoris*; H: *Salvio glutinosae-Quercetum roboris ass. nov*.

statistical analysis excludes a possible relationship with other elm-rich stands and supports the independence of this association which is included in *Carici remotae-Fraxinion oxycarpae* (Poldini and Sburlino 2018). Indeed, this coenosis has a contradictory floristic composition, showing a high expression of *Ulmus minor*, *Quercus robur* and *Carex pendula*, and it therefore takes an intermediate position between *Carici remotae-Fraxinion oxycarpae* and *Dioscoreo-Ulmion*: its poverty in species and strong degradation, stressed by Corbetta and Censoni Zanotti (1974), do not allow a univocal interpretation.

Furthermore, the cluster analysis does not support a possible relationship of the stands rich in *Populus alba*, which are included in group H, with the *Dioscoreo-Populion* forests (group F), as confirmed by the results of the PCA, in which *Dioscoreo-Populetum* is clearly separated from all the other relevès of cluster 2 along the third axis (not shown: 8.31 % of total variance).

Cluster 3 gathers the stands recorded by Guglielmetto Mugion and Montacchini (1993-94) from Lake Viverone (Piedmont), which are clearly separated from the other relevés (group I). These stands were originally attributed to *Querco-Ulmetum minoris* but they do not correspond to the association described by Issler (1924) for their completely different ecology and floristic structure. Indeed *Querco-Ulmetum minoris* is a riparian forest type occurring in the alluvial plains of the great rivers of Central Europe (Oberdorfer 1992), while the *Quercus robur* and *Fraxinus excelsior* woodland from Lake Viverone is definitely a lacustrine type with a swampy character, proved by the occurrence of *Frangula alnus*, *Salix cinerea*, *Carex elata*, *Thelypteris palustris*, *Galium palustre*, *Thysselinum palustre*. These lakeside stands deserve further investigations to clarify their syntaxonomical position.

On the whole, the statistical analysis allows the identification, besides *Asparago-Quercetum* (*Erythronio-Carpinion*) and *Rubo caesii-Ulmetum minoris* (*Carici remotae-Fraxinion oxycarpae*), of five alluvial/waterside elm-rich communities comprising the well-known *Polygonato-Quercetum*, *Lamio-Ulmetum* and three other forest types. The synthetic tables of the five *Ulmus minor*-rich woods from the Po Plain and the Karst were compared at the Italian and European level, considering corresponding elm-rich woods from central-southern Italy and Central Europe taken from the literature (Tab. 7). The synoptic table was subjected to hierarchical classification, which highlighted the affinity among the coenoses of northern Italy, grouping them into a single cluster (Fig. 3). Therefore, on the basis of floristic and ecological features, the five Po Plain-Karst forests rich in *Quercus robur* and/or *Ulmus minor* are included in the *Dioscoreo-Ulmion* alliance.

The synoptic table (Tab. 7) provides a representation of the floristic gradient of the coenoses and highlights the transitional character of the Po Plain-Karst elm-rich forests. Moreover, it allows a better characterization of *Dioscoreo-Ulmion* and the detection of the diagnostic species (preferential species sensu Biondi (2011)) of the associations. These hardwood forests are characterized by species of *Fagetalia* with a wide European distribution (such as *Carex sylvatica*, *Daphne mezereum*, *Paris quadrifolia*, *Polygonatum multiflorum*, *Salvia glutinosa*, *Viola reichenbachiana*), South-East European species of *Erythronio dentis-canis-Carpinion betuli* (such as *Lonicera caprifolium*, *Primula vulgaris*) and of *Aremonio agrimonioidis-Fagion sylvaticae* (such as *Lamium orvala*, *Asarum europaeum* s.l.), as well as by a group of differential species of *Dioscoreo-Ulmion* represented by *Vinca minor*, *Asparagus tenuifolius*, *Aristolochia clematitis*, *Leucojum aestivum*. In addition to these, there is a much larger group of Central European species (*Glechoma hederacea*, *Rhamnus cathartica*, *Viola hirta*), which, along with mesophilous elements (such as *Corylus avellana*) and sub-hygrophilous species in common with Central Europe (*Rubus caesius*, *Aegopodium podagraria*, *Humulus lupulus*, *Prunus padus*, *Parietaria officinalis*), differentiate these forests from southern elm woods. On the other hand, there is a group of south-

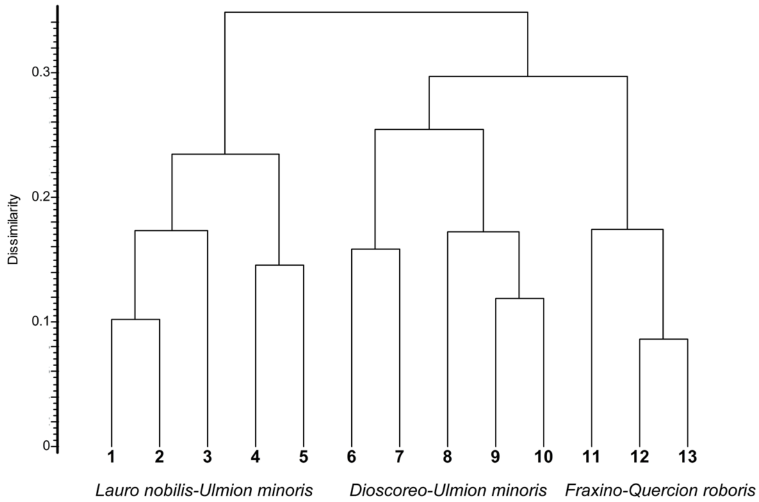

Figure 3. Cluster analysis (frequency data, Similarity ratio, Ward's method) of synthetic tables of Italian and European alluvial/waterside *Ulmus minor*-rich woods included in Tab. 7. Labels of synthetic tables as in Tab. 7.

Table 7. Synoptic table of Italian and European alluvial *Ulmus minor*-rich woods. Columns are arranged according to cluster analysis of Fig. 3. Species with frequency < 25 % are not reported in the table, except those with phytosociological significance. 1: *Aro italici-Ulmetum minoris* (Fanelli 2002); 2: *Lauro nobilis-Ulmetum minoris* (Biondi et al. 2015); 3: *Symphyto bulbosi-Ulmetum minoris* (Biondi and Allegrezza 1996); 4: *Periploco graecae-Ulmetum minoris* (Vagge and Biondi 1999); 5: *Lauro nobilis-Fraxinetum oxycarpae* (Allegrezza and Biondi 2002; Biondi et al. 2002); 6: *Rhamno catharticae-Ulmetum minoris ass. nov.* (Tab. 8 in this paper); 7: *Lamio orvalae-Ulmetum minoris* (Poldini et al. 2017); 8: *Polygonato multiflori-Quercetum roboris* (Sartori 1984; Assini 2011a); 9: *Vinco minoris-Ulmetum minoris ass. nov.* (Tab. 9 in this paper); 10: *Salvio glutinosae-Quercetum roboris ass. nov.* (orig. Tab. 1 rels. 1-7 sub "Boschi igrofili a *Populus alba*" by Cavani et al. 1981); 11: *Fraxino-Ulmetum typicum* (South-eastern Alps, orig. Tab. 18/3 by Drescher 2007a, 2007b); 12: *Fraxino-Ulmetum typicum* (Northern Alps, orig. Tab. 18/6 by Drescher 2007a, 2007b); 13: *Querco-Ulmetum* (Germany, orig. Tab. 302/8 by Seibert 1992). Cl: species of *Alno glutinosae-Populetea albae*.

	Number of column	1	2	3	4	5	6	7	8	9	10	11	12	13
	Number of relevés	20	26	10	5	7	14	7	42	35	7	15	35	811
		Lauro nobilis-Ulmion minoris					***Dioscoreo-Ulmion***					***Fraxino-Quercion roboris***		
	Euonymus europaeus L.	35.0	26.9	20.0	20.0	57.1	57.1	85.7	71.4	17.1	14.3	93.0	34.0	51.0
	Ligustrum vulgare L.	10.0	11.5	10.0	20.0	42.9	64.3	71.4	28.6	91.4	57.1	40.0	57.0	50.0
Cl	*Ulmus minor* Mill. subsp. *minor*	95.0	100.0	100.0	100.0	85.7	100.0	100.0	59.5	100.0	85.7	.	11.0	62.0
	Crataegus monogyna Jacq.	40.0	26.9	.	20.0	57.1	100.0	71.4	81.0	88.6	57.1	13.0	57.0	41.0
	Robinia pseudoacacia L.	5.0	23.1	.	40.0	14.3	14.3	57.1	33.3	62.9	42.9	13.0	3.0	3.0
	Sambucus nigra L.	10.0	50.0	60.0	.	28.6	.	100.0	9.5	37.1	28.6	27.0	26.0	18.0
Cl	*Brachypodium sylvaticum* (Huds.) P.Beauv.	5.0	57.7	.	40.0	71.4	71.4	100.0	21.4	11.4	.	87.0	74.0	86.0
	Prunus spinosa L. subsp. *spinosa*	25.0	26.9	20.0	60.0	57.1	28.6	14.3	2.4	14.3	.	.	3.0	22.0
	Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó and subsp. *australis* (C.A.Mey.) Jáv.)	15.0	30.8	.	.	28.6	92.9	57.1	42.9	100.0	42.9	60.0	91.0	65.0
	Galium aparine L.	55.0	.	100.0	.	28.6	7.1	71.4	2.4	22.9	.	47.0	6.0	29.0
	Acer campestre L.	45.0	23.1	.	.	.	21.4	100.0	26.2	14.3	.	.	9.0	19.0
Cl	*Alliaria petiolata* (M.Bieb.) Cavara & Grande	20.0	11.5	60.0	.	.	.	57.1	.	2.9	.	20.0	11.0	8.0
	Clematis vitalba L.	.	42.3	80.0	.	.	21.4	14.3	4.8	48.6	28.6	.	46.0	23.0
Cl	*Urtica dioica* L. s.l.	.	11.5	60.0	.	.	21.4	28.6	9.5	8.6	.	7.0	9.0	19.0
Cl	*Ficaria verna* Huds. s.l.	.	12.0	40.0	.	14.3	21.4	42.9	.	5.7	14.3	.	3.0	34.0
	Geum urbanum L.	.	8.0	.	.	57.1	35.7	85.7	.	2.9	.	80.0	20.0	20.0
Cl	*Populus nigra* L.	.	3.8	30.0	.	.	85.7	14.3	28.6	37.1	57.1	27.0	11.0	6.0
Cl	*Populus alba* L.	.	7.7	30.0	.	.	.	14.3	26.2	5.7	100.0	20.0	17.0	9.0
	Salix alba L.	.	11.5	30.0	.	.	21.4	.	.	5.7	.	.	.	6.0
	Alnus glutinosa (L.) Gaertn.	.	.	.	20.0	.	.	28.6	14.3	17.1	14.3	47.0	.	4.0
	Populus canescens (Aiton) Sm.	.	.	.	.	.	7.1	.	.	.	.	.	29.0	7.0
	Hedera helix L. subsp. *helix*	70.0	96.2	50.0	80.0	85.7	42.9	71.4	45.2	57.1	57.1	.	.	14.0
	Dioscorea communis (L.) Caddick & Wilkin	50.0	3.8	.	.	28.6	14.3	42.9	38.1	65.7	71.4	.	.	.
Cl	*Arum italicum* Mill. subsp. *italicum*	70.0	73.1	100.0	.	85.7	7.1	57.1	.	.	.	.	.	.
	Fraxinus ornus L. subsp. *ornus*	15.0	23.1	.	.	42.9	28.6	14.3	.	8.6	.	.	.	.
	Ruscus aculeatus L.	30.0	.	.	40.0	85.7	50.0	28.6	.	.	.	.	.	.
Cl	*Bryonia dioica* Jacq.	30.0	7.7	.	.	.	.	42.9	.	11.4	.	.	.	.
Cl	*Fraxinus angustifolia* Vahl subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso	.	15.4	.	20.0	100.0	92.9	71.4	.	.	.	.	.	.
Cl	*Clematis viticella* L.	.	3.8	.	.	42.9	71.4	14.3	.	.	.	.	.	.
Cl	*Carex pendula* Huds.	.	15.4	.	.	57.1	7.1	42.9	.	.	.	.	.	0.5
	Poa sylvicola Guss.	.	4.0	.	.	.	21.4	57.1	.	.	.	.	.	.
	Laurus nobilis L.	70.0	100.0	30.0	20.0	71.4	7.1	.	.	.	.	.	.	.
	Rubus ulmifolius Schott	40.0	80.8	80.0	80.0	42.9	21.4	.	.	2.9	.	.	.	.
	Rhamnus alaternus L. subsp. *alaternus*	15.0	19.2	10.0	60.0	28.6	.	.	.	.	.	.	.	.
	Rubia peregrina L.	20.0	46.2	30.0	80.0	71.4	.	.	.	.	.	.	.	.
	Asparagus acutifolius L.	30.0	23.1	.	40.0	71.4	14.3	.	.	.	.	.	.	.
	Smilax aspera L.	15.0	7.7	.	80.0	28.6	.	.	.	.	.	.	.	.
	Quercus ilex L. subsp. *ilex*	10.0	7.7	.	20.0	14.3	.	.	.	.	.	.	.	.
	Rosa sempervirens L.	30.0	15.4	.	60.0	100.0	.	.	.	.	.	.	.	.
	Quercus pubescens Willd. subsp. *pubescens*	35.0	.	40.0	20.0	.	7.1	.	.	.	.	.	.	.
	Ranunculus cfr. *velutinus* Ten.	15.0	.	40.0	.	71.4	.	.	.	.	.	.	.	.
	Symphytum bulbosum K.F.Schimp.	.	30.8	90.0	.	28.6	.	.	.	.	.	.	.	.
	Allium neapolitanum Cirillo	.	23.1	10.0	.	28.6	.	.	.	.	.	.	.	.
	Bellevalia romana (L.) Sweet	.	12.0	30.0	.	28.6	.	.	.	.	.	.	.	.
	Phillyrea angustifolia L.	.	3.8	.	40.0	.	.	.	.	.	.	.	.	.
	Lonicera etrusca Santi	.	7.7	.	20.0	.	.	.	.	.	.	.	.	.
	Pistacia lentiscus L.	.	3.8	.	20.0	.	.	.	.	.	.	.	.	.
	Quercus virgiliana (Ten.) Ten.	.	30.8	.	.	14.3	.	.	.	.	.	.	.	.
	Iris foetidissima L.	.	19.2	.	.	42.9	.	.	.	.	.	.	.	.

Table 7. Continuation.

	Number of column	1	2	3	4	5	6	7	8	9	10	11	12	13
	Number of relevés	20	26	10	5	7	14	7	42	35	7	15	35	811
		Lauro nobilis-Ulmion minoris					*Dioscoreo-Ulmion*					*Fraxino-Quercion roboris*		
	Cyclamen hederifolium Aiton	.	4.0	.	.	28.6	.	.	.	.	.	.	.	.
	Emerus major Mill. subsp. *emeroides* (Boiss. & Sprun-er) Soldano & F.Conti	.	4.0	.	.	28.6	.	.	.	.	.	.	.	.
	Viburnum tinus L. subsp. *tinus*	.	11.5	.	.	14.3	.	.	.	.	.	.	.	.
	Viola alba Besser subsp. *dehnhardtii* (Ten.) W.Becker	.	.	10.0	.	28.6	.	.	.	.	.	.	.	.
	Lonicera caprifolium L.	.	.	.	.	28.6	7.1	28.6	19.0	25.7	.	.	.	.
	Aristolochia clematitis L.	.	.	.	.	.	78.6	.	14.3	2.9	28.6	7.0	.	.
	Vinca minor L.	.	.	.	.	.	7.1	14.3	16.7	54.3	14.3	.	.	1.0
	Asparagus tenuifolius Lam.	.	.	.	.	.	21.4	14.3	45.2	.	14.3	.	.	.
	Ornithogalum divergens Boreau	.	.	.	.	.	14.3	.	.	2.9	28.6	.	.	.
	Lamium orvala L.	.	.	.	.	.	7.1	85.7	.	2.9	.	.	.	.
	Leucojum aestivum L.	.	.	.	.	.	64.3	28.6	.	.	.	.	.	.
	Primula vulgaris Huds. subsp. *vulgaris*	.	.	.	.	.	.	57.1	.	.	85.7	.	.	.
	Symphytum tuberosum L. subsp. *angustifolium* (A.Kern.) Nyman	.	.	.	.	42.9	.	28.6	9.5	.	42.9	67.0	29.0	1.0
	Corylus avellana L.	.	.	.	.	14.3	.	57.1	97.6	37.1	85.7	.	63.0	45.0
Cl	*Quercus robur* L. subsp. *robur*	5.0	.	.	.	.	14.3	71.4	100.0	91.4	100.0	80.0	34.0	58.0
Cl	*Rubus caesius* L.	.	4.0	.	.	.	64.3	85.7	52.4	91.4	42.9	73.0	77.0	73.0
Cl	*Humulus lupulus* L.	.	3.8	.	.	.	42.9	42.9	.	5.7	14.3	13.0	17.0	13.0
	Viola reichenbachiana Jord. ex Boreau (incl. *V. rivini-ana* Rchb. subsp. *riviniana*)	.	8.0	.	.	.	57.1	57.1	21.4	.	.	33.0	51.0	46.0
Cl	*Viburnum opulus* L.	.	.	.	.	.	28.6	.	11.9	11.4	.	33.0	46.0	32.0
	Carex sylvatica Huds.	.	.	.	.	.	28.6	71.4	7.1	2.9	.	60.0	37.0	51.0
	Glechoma hederacea L.	.	.	.	.	.	21.4	42.9	19.0	11.1	.	7.0	20.0	57.0
	Viola hirta L.	.	.	.	.	.	21.4	14.3	.	.	.	67.0	.	14.0
	Equisetum arvense L.	.	.	.	.	.	28.6	14.3	.	8.6	.	7.0	3.0	18.0
	Limniris pseudacorus (L.) Fuss	.	.	.	.	.	28.6	.	.	11.4	14.3	.	.	8.0
	Lysimachia vulgaris L.	.	.	.	.	.	28.6	.	.	.	.	20.0	3.0	6.0
	Fragaria vesca L. subsp. *vesca*	.	.	.	.	.	7.1	.	4.8	.	.	53.0	3.0	0.5
	Paris quadrifolia L.	.	.	.	.	.	.	14.3	9.5	.	28.6	20.0	63.0	63.0
	Neottia ovata (L.) Bluff & Fingerh.	.	.	.	.	.	.	14.3	.	2.9	71.4	53.0	17.0	25.0
	Polygonatum multiflorum (L.) All.	.	.	.	.	.	.	71.4	64.3	.	57.1	.	51.0	19.0
	Anemonoides nemorosa (L.) Holub	.	.	.	.	.	.	28.6	28.6	5.7	28.6	.	6.0	54.0
Cl	*Circaea lutetiana* L. subsp. *lutetiana*	.	.	.	.	.	.	57.1	7.1	2.9	.	.	9.0	29.0
	Allium ursinum L.	.	.	.	.	.	.	42.9	.	.	.	7.0	69.0	22.0
	Colchicum autumnale L.	.	.	.	.	.	.	14.3	.	.	.	53.0	14.0	24.0
	Prunus padus L.	.	.	.	.	.	.	14.3	45.2	.	.	40.0	26.0	59.0
	Aegopodium podagraria L.	.	.	.	.	.	.	28.6	.	20.0	.	73.0	77.0	59.0
	Galanthus nivalis L.	.	.	.	.	.	.	14.3	.	.	.	7.0	23.0	1.0
	Anemonoides ranunculoides (L.) Holub	.	.	.	.	.	.	42.9	.	2.9	.	.	6.0	33.0
	Angelica sylvestris L.	.	.	.	.	.	.	14.3	.	.	.	.	37.0	36.0
	Leucojum vernum L.	.	.	.	.	.	.	14.3	.	.	28.6	.	.	4.0
	Asarum europaeum L. s.l. (incl. subsp. *caucasicum* (Duch.) Soó)	.	.	.	.	.	.	.	2.4	37.1	71.4	100.0	74.0	35.0
	Salvia glutinosa L.	.	.	.	.	.	.	.	11.9	25.7	71.4	7.0	77.0	2.0
	Symphytum officinale L.	.	.	.	.	.	.	.	19.0	17.1	57.1	.	.	12.0
	Viburnum lantana L.	.	.	.	.	.	.	.	2.4	51.4	57.1	.	17.0	21.0
	Berberis vulgaris L.	.	.	.	.	.	.	.	.	2.9	14.3	.	26.0	14.0
	Daphne mezereum L.	.	.	.	.	.	.	.	.	2.9	28.6	.	3.0	22.0
	Deschampsia cespitosa (L.) P.Beauv. subsp. *cespitosa*	.	.	.	.	.	28.6	.	.	.	.	33.0	37.0	66.0
	Solidago gigantea Aiton	.	.	.	.	.	.	14.3	7.1	11.4	.	53.0	23.0	4.0
	Pulmonaria officinalis L.	.	.	.	.	.	.	.	11.9	8.6	.	67.0	49.0	10.0
	Convallaria majalis L.	.	.	.	.	.	.	.	69.0	.	.	7.0	29.0	22.0
	Melica nutans L.	.	.	.	.	.	.	.	42.9	.	.	47.0	43.0	38.0
	Moehringia trinervia (L.) Clairv.	.	.	.	.	.	.	.	35.7	.	.	27.0	6.0	6.0
	Dactylis glomerata L. s.l.	.	8.0	.	.	.	.	.	2.4	.	.	80.0	3.0	2.0
	Ajuga reptans L.	.	4.0	.	.	14.3	.	.	.	.	.	67.0	29.0	13.0
	Fraxinus excelsior L. subsp. *excelsior*	.	.	.	.	.	7.1	.	.	.	.	53.0	94.0	95.0
	Heracleum sphondylium L.	.	.	.	.	.	.	.	.	.	.	73.0	11.0	3.0
	Cirsium oleraceum (L.) Scop.	.	.	.	.	.	.	.	.	.	.	40.0	26.0	16.0
Cl	*Alnus incana* (L.) Moench	.	.	.	.	.	.	.	.	.	.	20.0	11.0	26.0
	Impatiens parviflora DC.	.	.	.	.	.	.	.	.	.	.	47.0	14.0	12.0

Table 7. Continuation.

		1	2	3	4	5	6	7	8	9	10	11	12	13
	Number of column	1	2	3	4	5	6	7	8	9	10	11	12	13
	Number of relevés	20	26	10	5	7	14	7	42	35	7	15	35	811
		Lauro nobilis-Ulmion minoris					***Dioscoreo-Ulmion***					***Fraxino-Quercion roboris***		
	Pimpinella major (L.) Huds.	.	.	.	.	.	.	.	.	.	.	**33.0**	**6.0**	**5.0**
	Tilia cordata Mill.	.	.	.	.	.	.	.	.	.	.	**27.0**	**20.0**	**13.0**
	Filipendula ulmaria (L.) Maxim.	.	.	.	.	.	.	.	.	.	.	**87.0**	**14.0**	**26.0**
Cl	*Ulmus laevis* Pall.	5.0	.	.	.	.	.	.	.	.	.	**47.0**	**14.0**	**8.0**
	Carduus personata (L.) Jacq.	.	.	.	.	.	.	.	.	.	.	**33.0**	**6.0**	**21.0**
	Primula elatior (L.) Hill	.	.	.	.	.	.	.	.	.	.	**13.0**	**51.0**	**46.0**
	Lolium giganteum (L.) Darbysh.	.	.	.	.	.	.	.	.	.	.	**20.0**	**3.0**	**26.0**
	Lysimachia nummularia L.	.	.	.	.	.	.	.	.	.	.	**27.0**	**11.0**	**3.0**
	Lamium galeobdolon (L.) L. subsp. *montanum* (Pers.) Hayek	.	.	.	.	.	.	14.3	.	.	.	**73.0**	**40.0**	.
	Carex alba Scop.	.	.	.	.	.	.	.	.	.	.	**7.0**	***<u>63.0</u>***	**25.0**
Cl	*Stachys sylvatica* L.	.	19.2	20.0	.	.	.	.	.	.	.	**7.0**	**46.0**	**64.0**
	Viola odorata L.	.	.	.	.	.	.	.	.	22.9	.	**7.0**	**46.0**	**2.0**
	Lonicera xylosteum L.	.	.	.	.	28.6	.	.	4.8	14.3	.	.	**60.0**	**59.0**
	Aconitum napellus L. emend. Skalický	.	.	.	.	.	.	.	.	.	.	.	**31.0**	**24.0**
	Acer pseudoplatanus L.	.	.	.	.	.	.	.	.	.	.	.	**26.0**	**61.0**
	Euphorbia dulcis L.	.	.	.	.	.	.	.	.	2.9	.	.	***<u>29.0</u>***	**0.5**
	Species of associations or subassociations						.							
	Melissa officinalis L. subsp. *altissima* (Sm.) Arcang.	.	**46.2**	.	.	.	.	.	.	.	.	.	.	.
	Rumex obtusifolius L. subsp. *obtusifolius*	.	.	**60.0**	.	.	.	.	.	.	.	.	.	.
	Sinapis alba L. s.l.	.	.	**50.0**	.	.	.	.	.	.	.	.	.	.
	Equisetum telmateia Ehrh.	.	8.0	**50.0**	.	.	.	14.3	.	.	.	.	.	.
	Ballota nigra L. s.l.	.	.	**40.0**	.	.	.	.	.	.	.	.	.	.
	Periploca graeca L.	.	.	.	**80.0**	.	.	.	.	.	.	.	.	.
	Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	4.0	.	**40.0**	.	.	.	.	.	.	.	.	3.0
	Agrostis stolonifera L. subsp. *stolonifera*	.	.	10.0	.	**42.9**	7.1	.	.	.	.	.	.	1.0
	Carex flacca Schreb. s.l.	.	.	.	.	**28.6**	.	.	.	.	.	.	.	15.0
	Rhamnus cathartica L.	5.0	.	.	.	.	**85.7**	28.6	.	8.6	.	.	6.0	11.0
	Bidens frondosa L.	.	.	.	.	.	**64.3**	.	.	.	.	.	.	.
	Campanula trachelium L. subsp. *trachelium*	.	.	.	.	.	**64.3**	.	.	.	.	7.0	14.0	20.0
	Frangula alnus Mill. subsp. *alnus*	.	.	.	.	.	**57.1**	.	2.4	8.6	.	.	11.0	14.0
	Clematis recta L.	.	.	.	.	.	**50.0**	14.3	.	.	.	.	.	.
	Prunella vulgaris L. subsp. *vulgaris*	.	.	.	.	.	**50.0**	.	4.8	.	.	13.0	.	.
	Galium palustre L. s.l. (subsp. *elongatum* (C.Presl) Lange p. max p.)	.	.	.	.	.	**42.9**	.	4.8	.	.	.	.	1.0
	Ranunculus repens L.	.	.	.	.	.	**35.7**	.	.	.	.	.	3.0	1.0
	Carex elata All. subsp. *elata*	.	.	.	.	.	**28.6**	.	.	.	.	.	.	0.5
	Potentilla indica (Andrews) Th.Wolf	.	.	.	.	.	.	**57.1**	.	.	.	.	.	.
	Loncomelos pyrenaicus (L.) L.D.Hrouda	15.0	.	.	.	.	.	**42.9**	.	.	.	.	.	.
	Parietaria officinalis L.	.	.	.	.	.	.	**42.9**	.	14.3	.	.	.	.
	Phalaris arundinacea L. subsp. *arundinacea*	.	.	.	.	.	.	**42.9**	.	.	.	.	.	12.0
	Platanus hispanica Mill. ex Münchh.	.	.	.	.	.	.	**28.6**	.	5.7	.	.	.	.
	Helleborus odorus Waldst. & Kit.	.	.	.	.	.	.	**28.6**	.	.	.	.	.	.
	Veratrum album L. subsp. *lobelianum* (Bernh.) Arcang.	.	.	.	.	.	.	**28.6**	.	.	.	.	.	.
	Cornus mas L.	.	4.0	.	.	.	.	.	**57.1**	2.9	.	.	11.0	1.0
	Carpinus betulus L.	.	.	.	.	.	.	.	**28.6**	.	.	20.0	.	12.0
	Galeopsis pubescens Besser	.	.	.	.	.	.	.	**42.9**	8.6	.	.	.	.
	Malus sylvestris (L.) Mill. (incl. *M. domestica* (Borkh.) Borkh.)	.	.	.	.	.	.	.	**42.9**	.	14.3	.	.	5.0
	Solanum dulcamara L.	.	3.8	.	.	.	7.1	.	.	**28.6**	.	.	.	2.0
	Lonicera japonica Thunb.	.	4.0	.	.	.	.	.	.	**25.7**	.	.	.	.
	Aegonychon purpurocaeruleum (L.) Holub	10.0	.	.	.	.	.	.	.	.	**57.1**	.	.	.
	Viola canina L. subsp. *canina*	.	.	.	.	.	.	.	4.8	22.9	**42.9**	.	.	.
	Isopyrum thalictroides L.	.	.	.	.	.	.	.	.	.	**42.9**	.	.	.
	Leontodon hispidus L. s.l.	.	.	.	.	.	.	.	.	.	.	**77.0**	.	.
	Rudbeckia laciniata L.	.	.	.	.	.	.	.	.	.	.	**60.0**	.	.
	Geranium phaeum L.	.	.	.	.	.	.	.	.	.	.	**53.0**	.	.
	Oxalis stricta L.	.	.	.	.	.	.	.	.	2.9	.	**47.0**	.	.
	Rumex acetosa L.	.	.	.	.	.	.	.	.	.	.	**40.0**	.	0.5
	Cardamine impatiens L. subsp. *impatiens*	.	.	.	.	.	7.1	.	.	.	.	**33.0**	.	1.0

Table 7. Continuation.

Number of column	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of relevés	20	26	10	5	7	14	7	42	35	7	15	35	811
	Lauro nobilis-Ulmion minoris					***Dioscoreo-Ulmion***					***Fraxino-Quercion roboris***		
Chaerophyllum hirsutum L.	.	.	.	.	.	.	.	.	.	.	**33.0**	.	0.5
Ornithogalum umbellatum L.	.	.	.	.	.	.	.	.	.	.	**33.0**	.	.
Poa palustris L.	.	.	.	.	.	.	.	.	.	.	**27.0**	.	0.5
Cerastium sylvaticum Waldst. & Kit.	.	.	.	.	.	.	.	.	.	.	**27.0**	.	.
Scilla bifolia L.	.	.	.	.	.	.	.	.	.	.	.	.	**47.0**
Carex acutiformis Ehrh.	.	.	.	.	.	.	.	4.8	.	.	.	.	**42.0**
Pulmonaria obscura Dumort.	.	.	.	.	.	.	.	.	.	.	.	.	**38.0**
Viola mirabilis L.	.	.	.	.	.	.	.	.	.	.	.	9.0	**30.0**
Arum maculatum L.	.	.	.	.	.	.	.	.	.	.	.	.	**25.0**

ern species (*Arum italicum*, *Dioscorea communis*, *Fraxinus ornus*, *F. angustifolia* subsp. *oxycarpa*, *Hedera helix*, *Ruscus aculeatus*, *Bryonia dioica*) that can be considered as differential entities of the *Dioscoreo-Ulmion* forests from the Central European *Fraxino-Quercion roboris* ones. In the synoptic table these groups of species give rise to an imbricate (overlapping) arrangement, which reflects the temperature gradient that occurs in the contact areas between different macrobioclimates. *Dioscoreo-Ulmion* differs from the Mediterranean/submediterranean alliance *Lauro nobilis-Ulmion minoris* for the scarceness of Mediterranean species, and from *Alnion incanae* for the shortage of *Fagetalia* entities and the occurrence of southern lianas (such as *Bryonia dioica*, *Dioscorea communis*, *Hedera helix*) and *Prunus spinosa* (Poldini et al. 2017).

Dioscoreo-Ulmion was originally placed in the class *Querco-Fagetea* by Poldini et al. (2017). In the light of the new relevés, making prevail the concept of azonality in agreement with Mucina et al. (2016) and considering the weakening of *Fagetalia* elements compared to the ecologically corresponding coenoses of Central Europe, it is now considered appropriate to move the alliance into the class *Alno glutinosae-Populetea albae* and the order *Populetalia albae*.

Multivariate analysis of data of Tab. 7 highlights the macroclimatic gradient underlying the different coenoses. The dendrogram of Fig. 3 shows a clear separation of the Mediterranean group of coenoses from the submediterranean-Central European one: this indicates a greater affinity of *Dioscoreo-Ulmion* associations with Temperate communities than Mediterranean ones. Successively, the submediterranean Po Plain-Karst group is distinguished from the Temperate one. This clear separation is also confirmed by the indirect gradient analysis (Fig. 4), where the submediterranean communities take an isolated and intermediate position between the Mediterranean and Central European groups, which reflects their transitional floristic composition.

On the basis of these analyses, the content of the transitional climate alliance *Dioscoreo-Ulmion* is expanded to include meso-hygrophilous and mesophilous hardwood *Ulmus minor-Quercus robur*-rich forests occurring in the lowlands of the Po Plain along the river systems and their alluvial plains as well as around karstic lakes (Suppl. material 2, Tab. S1). They are elm or oak-elm forests with or without *Fraxinus* spp. that grow on clay soils mixed with fine gravel to fine sandy-silty or sandy-fine gravelly soils, with more or less superficial water table and variable soil moisture conditions between the inundations, which may be due to higher phases of normal high water or exceptional floods of rivers or lakes, or to the rising of the water table.

Lamio orvalae-Ulmetum minoris is the type association of the alliance described from the resurgence rivers of the Friulian Plain; further differential species can be deduced from Suppl. material 2, Tab. S1 in addition to those identified by Poldini et al. (2017).

Polygonato-Quercetum roboris and the two new associations *Vinco minoris-Ulmetum minoris* and *Salvio glutinosae-Quercetum roboris* correspond to forest types of the central-western Po Plain originally assigned to *Alno-Padion* or other synonyms of *Alnion incanae*. In the latest Vegetation Prodrome of Italy (Biondi and Blasi 2015) this critical alliance is classified in the class *Querco-Fagetea* and subdivided in the suballiances *Alnenion glutinoso-incanae* and *Ulmenion minoris*. Conversely, Mucina et al. (2016) include hardwood alluvial forests with azonal character in *Alno glutinosae-Populetea albae*, and separate the elm-ash and oak communities formerly included in *Ulmenion* in the *Fraxino-Quercion roboris* alliance, kept distinct from *Alnion incanae*. Therefore, while for the "nemoral" Europe Mucina et al. (2016) classify the azonal riparian floodplain forests in *Alnion incanae* and *Fraxino-Quercion roboris* (*Alno-Fraxinetalia excelsioris*), thus, symmetrically, in the lowlands of Northern Italy, these two alliances are replaced by *Ligustro vulgaris-Alnion glutinosae*, including riverside *Alnus glutinosa*-rich forests on organic-peaty soils, and *Dioscoreo-Ulmion minoris*, spread on clay to sandy-fine gravelly soils, the two alliances both belonging to *Populetalia*. Hence, *Polygonato-Quercetum* cannot be included in *Alnion incanae* nor in *Erythronio-Carpinion*, but it is well placed in *Dioscoreo-Ulmion* for its moderate southern character (Tab. 7); Suppl. material 2, Tab. S1 allows to identify the differential species of this forest type. The new riparian associations *Vinco-Ulmetum* and *Salvio-Quercetum* encompass stands that cannot be assigned to *Alnion incanae* for the same reasons.

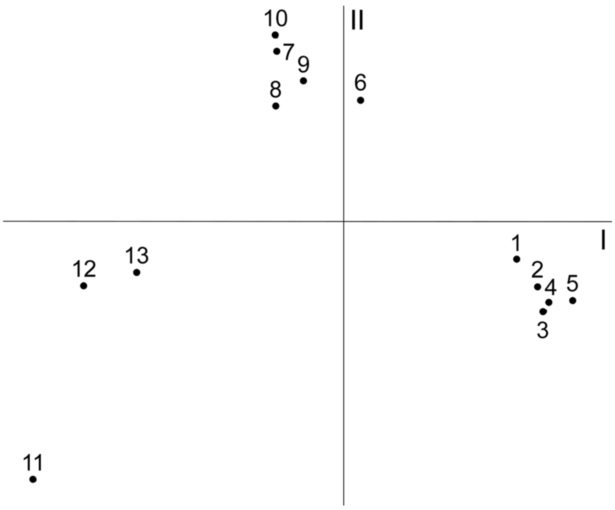

Figure 4. PCA of synthetic tables of Italian and European alluvial/waterside *Ulmus minor*-rich woods included in Tab. 7. (First component: 29.05 % of total variance, second component: 14.91 %). Labels of synthetic tables as in Tab. 7.

Ass.: *RHAMNO CATHARTICAE-ULMETUM MINORIS* Poldini, Vidali & Castello *ass. nov*. (Tab. 8)

Holotypus: rel. 3 of Tab. 8 in this paper.

Pseudonyms: *Carpino betuli-Quercetum roboris* sensu Poldini 1989 non (Anić 1959) em. Rauš 1969; *Salicetum albae* sensu Poldini 1989 non Issler 1926.

Diagnostic species: *Rhamnus cathartica*, *Bidens frondosa*, *Prunella vulgaris* subsp. *vulgaris*, *Clematis recta*, *Ranunculus repens*, *Frangula alnus* subsp. *alnus*, *Galium palustre* subsp. *elongatum*, *Campanula trachelium* subsp. *trachelium*, *Carex elata* subsp. *elata*, *Lysimachia vulgaris*, *Ruscus aculeatus*.

Structure and composition: Mixed broadleaved forest with a rather closed-canopy dominated by *Ulmus minor*, *Fraxinus angustifolia* subsp. *oxycarpa* and *Populus nigra*. *Ulmus minor* is mainly concentrated in the lower tree layer, accompanied by *Fraxinus ornus*, *Acer campestre*, *Salix alba* and sporadic *Quercus robur*. The shrub layer is rather well developed and characterized by *Rhamnus cathartica*, *Frangula alnus* and *Rubus caesius*, accompanied by various *Rhamno-Prunetea* shrubs and small individuals of *U. minor* and *F. ornus*; *U. minor* shows a remarkable regeneration in the undergrowth. The liana layer is made up mainly of *Clematis viticella* and *Hedera helix*. The herbaceous layer is rather poorly developed and discontinuous, including species such as *Aristolochia clematitis*, *Asparagus tenuifolius*, *Brachypodium sylvaticum*, *Clematis recta*, *Deschampsia cespitosa*, *Viola reichenbachiana* and the exotic *Bidens frondosa*; at Lake Doberdò it is characterized by the extensive flowering of *Leucojum aestivum* in the spring.

Two main aspects of this lacustrine elm wood can be recognized. In areas closer to the water an aspect with abundant *Populus nigra* occurs (rels. 1-7, Tab. 8): in the tree layer the black poplar is often accompanied by *Salix alba*, *Frangula alnus* is often present and the herbaceous layer is characterized by abundant *Aristolochia clematitis*, *Leucojum aestivum*, and other hygrophilous and sub-hygrophilous entities such as *Galium palustre* subsp. *elongatum*, *Carex elata*, *Ranunculus repens*, *Equisetum arvense*, *Prunella vulgaris*. The second aspect (rels. 8-12) is found in more rarely flooded sites, where *Populus nigra* is less abundant or absent, *Salix alba* disappears, *Ulmus minor* may join with abundant *Fraxinus angustifolia* subsp. *oxycarpa*; the shrub layer is more developed and species-rich; in the herbaceous layer *Carex sylvatica*, *Deschampsia cespitosa* and *Geum urbanum* are frequent.

Syntaxonomy: The analysis of the *Ulmus minor*-rich forests at the Italian and European level (Figs. 1-2) showed the autonomy of the karstic lakeshore stands, here described as a new association which can be assigned to *Alno-Populetea* on the basis of the considerable frequency of numerous elements of this class, and included in *Dioscoreo-Ulmion* on the basis of the presence of (sub-)mediterranean entities such as *Dioscorea communis*, *Hedera helix*, *Arum italicum*, *Fraxinus ornus*, *Ruscus aculeatus*, *Rubus ulmifolius*, *Asparagus acutifolius*, some species of *Fagetalia* and entities of the alliance (Tabs. 7, 8, and Suppl. material 2, Tab. S1).

Given the high frequency of *Ulmus minor*, *Fraxinus angustifolia* subsp. *oxycarpa*, *Rubus caesius* and *Clematis viticella*, a possible relationship with *Rubo caesii-Ulmetum minoris* from the River Reno was considered, but the statistical analysis (Figs. 1-2) confirmed the independence of *Rubo-Ulmetum* from the karstic *Rhamno-Ulmetum*, which is well-differentiated by the high frequency of species not present in *Rubo-Ulmetum* such as *Rhamnus cathartica*, *Aristolochia clematitis*, *Leucojum aestivum*, *Campanula trachelium*, *Crataegus monogyna*, *Viola reichenbachiana*.

Compared to the other coenoses of the alliance, *Rhamno-Ulmetum* is characterized by elements linked to lentic habitats such as *Frangula alnus*, *Carex elata* and *Galium palustre* subsp. *elongatum* (Suppl. material 2, Tab. S1). Its peculiarity with respect to the other *Dioscoreo-Ulmion* forests can be well highlighted by including in the analysis swamp communities of the class *Alnetea glutinosae*, namely *Valeriano dioicae-Fraxinetum oxycarpae*, described from the same karstic wetlands (Poldini and Sburlino 2018) and *Cladio-Fraxinetum oxycarpae* (*Frangulo-Fraxinion oxycarpae*). The dendrogram of Fig. 5 shows the connection of *Rhamno-Ulmetum* with *Dioscoreo-Ulmion* woods; the PCA (Fig. 6) confirms the results of the cluster analysis, but highlights the peculiar position taken by *Rhamno-Ulmetum* towards the other coenoses, which are arranged in the diagram along a gradient of decreasing soil moisture and water availability, from the wettest extreme given by *Cladio-Fraxinetum* and *Valeriano-Fraxinetum* to the least wet one represented by the mesophilous aspects of *Polygonato-Quercetum* with *Anemonoides nemorosa*. In the PCA *Rhamno-Ulmetum* takes an intermediate position, revealing its transitional character towards truly swamp forests of *Frangulo-Fraxinion*. This peculiar transitional character is strongly con-

Table 8. *Rhamno catharticae-Ulmetum minoris ass. nov*. Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Complete linkage). d ass: differential species of association.

	Relevé number	1	2	3*	4	5	6	7	8	9	10	11	12	13	14	
	Area (m²)	200	200	200	300	200	400	300	400	200	400	200	200	300	200	
	No. of species (incl. sporadic species)	27	28	24	16	23	21	22	33	39	28	23	25	22	23	Fr.
	Diagnostic species of the association															
d ass	*Rhamnus cathartica* L.	1	1	1	2	1	2	1	1	1	.	+	.	+	1	85.7
d ass	*Bidens frondosa* L.	1	+	1	.	.	2	1	+	1	.	+	1	.	.	64.3
d ass	*Prunella vulgaris* L. subsp. *vulgaris*	+	.	1	.	1	+	.	+	.	.	.	.	+	+	50.0
d ass	*Clematis recta* L.	.	+	1	1	1	.	1	+	+	.	.	.	.	.	50.0
d ass	*Ranunculus repens* L.	1	+	1	.	.	+	1	.	.	.	.	.	.	.	35.7
	Species of *Dioscoreo-Ulmion minoris*															
	Aristolochia clematitis L.	3	2	+	2	2	1	1	2	1	1	+	.	.	.	78.6
	Leucojum aestivum L.	2	2	3	.	2	1	1	1	1	1	.	.	.	.	64.3
	Asparagus tenuifolius Lam.	.	.	.	.	.	.	.	1	+	1	.	.	.	.	21.4
	Dioscorea communis (L.) Caddick & Wilkin	.	.	.	.	.	.	.	.	.	.	+	1	.	.	14.3
	Lonicera caprifolium L.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	7.1
	Vinca minor L.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7.1
	Species of *Alno glutinosae-Populetea*															
	Ulmus minor Mill. subsp. *minor*	4	3	4	2	3	3	1	3	2	2	2	2	3	3	100.0
	Fraxinus angustifolia Vahl subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso	2	1	2	.	1	+	+	3	2	4	3	3	2	1	92.9
	Populus nigra L.	3	3	3	3	3	3	3	.	1	2	2	2	1	.	85.7
	Brachypodium sylvaticum (Huds.) P.Beauv.	1	2	1	.	1	.	.	1	2	1	.	2	1	1	71.4
	Clematis viticella L.	1	1	1	1	1	1	2	2	1	.	.	1	.	.	71.4
	Rubus caesius L.	1	.	2	2	.	3	2	+	1	1	+	.	.	.	64.3
	Humulus lupulus L.	.	+	.	+	+	+	.	.	+	1	.	.	.	.	42.9
	Viburnum opulus L.	.	.	.	.	.	.	.	.	.	1	1	.	1	+	28.6
	Ficaria verna Huds. s.l.	.	.	.	+	.	.	.	.	1	+	.	.	.	.	21.4
	Urtica dioica L. subsp. *dioica*	.	.	.	.	+	.	+	.	1	.	.	.	.	.	21.4
	Quercus robur L. subsp. *robur*	.	1	.	.	1	.	.	.	.	.	.	.	.	.	14.3
	Species of *Alnetea glutinosae* and *Alnetalia glutinosae*															
d ass	*Frangula alnus* Mill. subsp. *alnus*	.	+	1	.	1	1	1	+	.	+	.	.	.	1	57.1
d ass	*Galium palustre* L. subsp. *elongatum* (C.Presl) Lange	.	1	1	.	.	1	.	+	+	.	1	.	.	.	42.9
	Salix cinerea L.	.	.	.	1	+	.	.	.	.	1	.	.	.	.	21.4
	Thelypteris palustris Schott	.	.	.	.	.	.	.	.	.	.	.	.	+	+	14.3
	Species of *Rhamno-Prunetea*															
	Crataegus monogyna Jacq.	+	1	2	1	1	+	1	2	1	+	1	2	1	+	100.0
	Cornus sanguinea L. subsp. *hungarica* (Kárpáti) Soó	1	1	2	2	2	1	+	.	.	2	+	1	2	2	85.7
	Ligustrum vulgare L.	.	1	+	+	1	.	.	+	2	.	.	2	1	1	64.3
	Euonymus europaeus L.	+	+	+	.	.	.	.	+	.	.	+	1	+	+	57.1
	Hedera helix L. subsp. *helix*	.	.	.	.	.	.	.	+	.	+	+	1	+	+	42.9
	Prunus spinosa L. subsp. *spinosa*	+	.	.	.	.	.	.	+	1	.	.	1	.	.	28.6
	Clematis vitalba L.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	21.4
	Acer campestre L.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	21.4
	Cornus sanguinea L. subsp. *australis* (C.A.Mey.) Jáv.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	7.1
	Species of *Fagetalia*															
d ass	*Campanula trachelium* L. subsp. *trachelium*	.	+	+	+	+	.	.	+	+	+	.	.	+	+	64.3
	Viola reichenbachiana Jord. ex Boreau (incl. *V. riviniana* Rchb. subsp. *riviniana*)	+	1	1	.	2	.	.	2	1	+	r	.	.	.	57.1
	Carex sylvatica Huds.	.	.	.	.	.	.	.	+	2	2	1	.	.	.	28.6
	Crocus heuffelianus Herb.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	14.3
	Species of *Querco-Fagetea*															
	Vincetoxicum hirundinaria Medik. subsp. *laxum* (Bartl.) Poldini	+	1	.	.	.	.	.	1	+	.	.	.	.	.	28.6
	Fraxinus ornus L. subsp. *ornus*	.	.	.	.	.	.	.	+	1	.	.	+	.	+	28.6
	Species of *Phragmito-Magnocaricetea*															
	Limniris pseudacorus (L.) Fuss	+	+	.	.	.	.	.	+	+	.	.	.	.	.	28.6
d ass	*Carex elata* All. subsp. *elata*	.	.	.	1	.	2	3	.	.	1	.	.	.	.	28.6
d ass	*Lysimachia vulgaris* L.	.	.	.	.	+	1	3	.	.	+	.	.	.	.	28.6
	Mediterranean elements															
d ass	*Ruscus aculeatus* L.	+	+	.	.	.	.	.	+	1	1	.	.	1	2	50.0
	Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	1	.	2	1	.	21.4
	Asparagus acutifolius L.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	14.3
	Arum italicum Mill. subsp. *italicum*	.	.	.	.	.	.	.	.	.	.	.	1	.	.	7.1

Table 8. Continuation.

Relevé number	1	2	3*	4	5	6	7	8	9	10	11	12	13	14	
Area (m^2)	200	200	200	300	200	400	300	400	200	400	200	200	300	200	
No. of species (incl. sporadic species)	27	28	24	16	23	21	22	33	39	28	23	25	22	23	Fr.
Other species															
Equisetum arvense L.	+	.	+	.	.	+	2	.	.	.	.	.	.	.	28.6
Geum urbanum L.	.	+	.	.	.	.	.	1	1	.	+	1	.	.	35.7
Thalictrum lucidum L.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	21.4
Salix alba L.	.	.	.	1	2	.	1	.	.	.	.	.	.	.	21.4
Deschampsia cespitosa (L.) P.Beauv. subsp. *cespitosa*	.	.	.	.	.	.	.	+	1	1	1	.	.	.	28.6
Glechoma hederacea L.	.	.	.	.	.	.	.	1	.	1	+	.	.	.	21.4
Poa sylvicola Guss.	.	.	.	.	.	.	.	+	2	.	.	+	.	.	21.4
Viola hirta L.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	21.4
Viola elatior Fr.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	14.3

ditioned by the particular hydrodynamic regime of the Karst lakes, which is characterized by strong and rapid vertical fluctuations of the water level, so that the entire lakeshore geosigmetum of the Karst lakes system is made up of elements belonging to the swamp woods of *Alnetea glutinosae* as well as to the fluvial ones of *Alno-Populetea*. Furthermore, compared to the other associations of the alliance, *Rhamno-Ulmetum* is distinguished by a greater thermophily that is expressed by entities such as *Rubus ulmifolius*, *Asparagus acutifolius* and *Quercus pubescens*, transgressive from *Lauro nobilis-Ulmion minoris* (Tab. 7).

This community shows a certain affinity with *Ulmo-Fraxinetum angustifoliae* ass. prov., a coenosis dominated by *Fraxinus angustifolia* and *Ulmus minor* identified by Horvat (1962) for karst dolines inundated in autumn and spring in north-western Croatia, which has never been formalized later. The two communities share various species such as *Aristolochia clematitis*, *Brachypodium sylvaticum*, *Campanula trachelium*, *Clematis recta*, *Prunella vulgaris*, *Rubus caesius*. The Croatian forest community appears to be a more mesic type, due to the presence of *Carpinus betulus*, *Corylus avellana*, *Lamium orvala*, *Thalictrum aquilegiifolium*.

Synecology: This is a meso-hygrophilous forest, found on the banks of karstic lakes and karstic springs (limnocrenes) in lowland areas, strongly conditioned by the particular hydrodynamics of the Karst lakes. It is spread in the parts of the banks that are periodically inundated, but not for long periods, at peaks of seasonal high water, mainly in spring and autumn. Water movements are fundamentally vertical, with large variations in height that can occur in a few days: at Lake Doberdò the fluctuations of water level can be higher than 6 m (Cucchi et al. 2000; Samez et al. 2005). Soils are neutral and correspond mainly to a complex of alluvial and colluvial silt loam, very poorly drained and temporarily saturated hydromorphic soils with no gravel and with a good content of organic matter (hydromor), and silty-clay loam or silt loam thin soils rich in gravel and excessively drained, developed on carbonate substrates (Michelutti et al. 2006); soils may be well drained during low water periods due to the underlying carbonate rocks and are not peaty.

The floristic variation within the association can be correlated with frequency and length of flooding and water-content of soil. Three main aspects can be observed.

The aspect with abundant *Populus nigra* (rels. 1-7 of Tab. 8), observed at Lake Doberdò, represents a more hygrophilous vegetation occurring in low-lying areas of the banks close to the water body and subject to more frequent and prolonged flooding; these sites are characterized by high water table and wetter and damper soils which, although highly fertile, may adversely affect the black poplar. *P. nigra* often dominates in the upper tree layer, and it may have been favoured by human activities in the past. However, at present the black poplar is not regenerating, while a remarkable vitality and recruitment of *Ulmus minor*, often accompanied by *Fraxinus angustifolia* subsp. *oxycarpa*, can be noticed: *U. minor* is currently abundant in the lower tree layer and the present wood with prevailing *P. nigra* is likely to turn into an *U. minor* wood within a short time, as result of the ongoing natural turnover of the black poplar with the field elm. Therefore this vegetation is interpreted as an aspect of an elm wood. A rather similar situation of lakeshore woods dominated by *Populus nigra* which may be accompanied by abundant *Ulmus minor* is reported by Lastrucci et al. (2014) from Tuscany. The aspect with *Ulmus minor* and *Fraxinus angustifolia* subsp. *oxycarpa* (rels. 8-12) is found in the outer parts of the banks of Lake Doberdò or bordering minor karstic water bodies; compared to the aspect with *Populus nigra*, it grows on soils which are more rarely flooded or becoming drier between flooding events. A further aspect with *Crocus heuffelianus*, *Vinca minor* and *Thelypteris palustris* (rels. 13-14) is found at the Karst lakes of Pietrarossa and Sablici.

Dynamic contacts: *Rhamno-Ulmetum* can be considered as the mature stage of the meso-hygrophilous dynamic series of vegetation of the upper banks of karstic lakes that are regularly but not long-flooded by seasonal high water, on alluvial/colluvial soils on carbonate substrates. The meso-hygrophilous *Ulmo-Paliuretum* introduced in this paper can be considered the mantle of this woodland.

Catenal contacts: It forms the hardwood forest at the back of swamp willow woods and scrubs with *Salix alba*

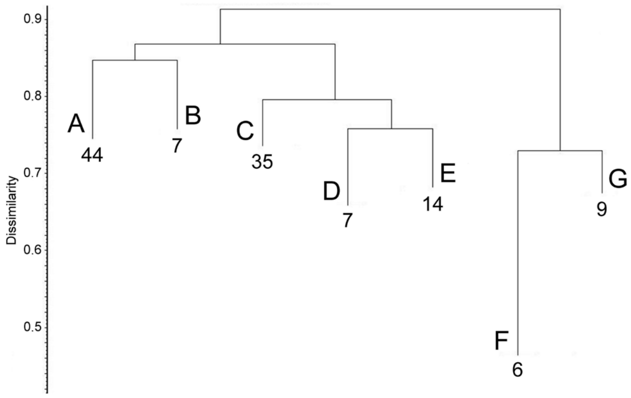

Figure 5. Cluster analysis (cover data, Similarity ratio, WPGMA) of relevés of alluvial/waterside Po Plain and karstic *Ulmus minor*-rich forests and *Fraxinus angustifolia* subsp. *oxycarpa* swamp forests of *Frangulo-Fraxinion*. Simplified dendrogram with major groups of relevés and number of relevés occurring in each group. A: *Polygonato-Quercetum roboris* (from Sartori 1984; Assini 2011a); B: *Salvio glutinosae-Quercetum roboris ass. nov*. (Tab. 1, rels. 1-7 in Cavani et al. 1981, sub “Boschi igrofili a *Populus alba*”); C: *Vinco minoris-Ulmetum minoris ass. nov*. (Tab. 9 in this paper); D: *Lamio-Ulmetum minoris* (Poldini et al. 2017); E: *Rhamno catharticae-Ulmetum minoris ass. nov*. (Tab. 8 in this paper); F: *Valeriano-Fraxinetum oxycarpae* (Poldini and Sburlino 2018); G: *Cladio-Fraxinetum oxycarpae* (Merloni and Piccoli 2001).

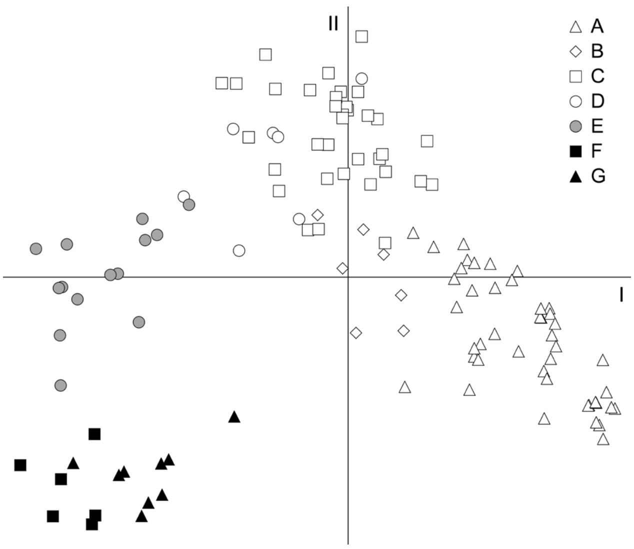

Figure 6. PCA of relevés of alluvial/waterside Po Plain and karstic *Ulmus minor*-rich forests and *Fraxinus angustifolia* subsp. *oxycarpa* swamp forests of *Frangulo-Fraxinion* (First component: 18.31 % of total variance, second component: 11.83 %). Relevés are grouped and labelled according to the dendrogram of Fig. 5. A: *Polygonato-Quercetum roboris*; B: *Salvio glutinosae-Quercetum roboris ass. nov*.; C: *Vinco minoris-Ulmetum minoris ass. nov*.; D: *Lamio-Ulmetum minoris*; E: *Rhamno catharticae-Ulmetum minoris ass. nov*.; F: *Valeriano-Fraxinetum oxycarpae*; G: *Cladio-Fraxinetum oxycarpae*.

and *S. cinerea* (*Galio-Salicetum albae*, *Frangulo-Salicetum cinereae*); in contact waterward also with helophytic communities of *Phragmito-Magnocaricetea*, landward with karstic deciduous woodlands (*Aristolochio luteae-Quercetum pubescentis*, *Ornithogalo pyrenaici-Carpinetum betuli*).

Synchorology: Karst area (Friuli-Venezia Giulia) (Suppl. material 1, Fig. S1).

Annex I Habitat (92/43/EEC Directive): 91F0.

Ass.: *VINCO MINORIS-ULMETUM MINORIS* Poldini, Vidali & Castello *ass. nov*. (Tab. 9)

Holotypus: rel. 9 of Tab. 9 in this paper.

Pseudonyms: *Querco-Ulmetum minoris* sensu Auct. Ital. p.p. non Issler 1924; *Polygonato multiflori-Quercetum roboris* sensu Bracco, Sartori & Terzo 1984 non Sartori 1984.

Corresponding names: "Boschetti di Olmo e Farnia" in Sartori and Zucchi (1981); "Querceto misto a *Quercus robur* e *Ulmus minor*" in Cavani et al. (1981).

Diagnostic species: *Vinca minor*. It is also to highlight the high presence of *Viburnum lantana* in the shrub layer, which is shared with *Salvio glutinosae-Quercetum roboris* hereafter described.

Structure and composition: See the original works by Cavani et al. (1981), Sartori and Zucchi (1981), Bracco et al. (1984) and Assini (1998). The general structure of this hardwood oak-elm forest can be outlined as follows. The tree layer is generally medium developed and is dominated by *Quercus robur* and *Ulmus minor*, accompanied by *Robinia pseudoacacia*, *Populus nigra* and sometimes *Alnus glutinosa*, *Populus alba* and *Salix alba*. The shrub layer is rather well developed, with a discontinuous cover; common species are *Rubus caesius*, *Crataegus monogyna*, *Cornus sanguinea*, *Ligustrum vulgare*, *Viburnum lantana*, along with young individuals of *Ulmus minor*, *Quercus robur* and *Robinia pseudoacacia*. The climbing species are well represented, particularly by *Dioscorea communis*, *Hedera helix*, *Clematis vitalba*, along with *Lonicera caprifolium* and *L. japonica*. The herbaceous layer is often poorly developed and discontinuous, and is dominated by seedlings of the main woody species. *Vinca minor* stands out for its frequency and abundance; facies with *Hedera helix*, *Aegopodium podagraria*, *Anemonoides nemorosa* and *Ficaria verna* occur locally.

Syntaxonomy: The statistical analysis (Figs. 1, 5) allowed to refer to a single new association the riverside oak-elm communities called "boschetti di Olmo e Farnia" by Sartori and Zucchi (1981) and "querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. (1981) (respectively along the rivers Oglio and Adda), originally classified in *Alno-Padion*, along with the disturbed woodland along the River Po near Frascarolo tentatively attributed to *Polygonato-Quercetum roboris* by Bracco et al. (1984), and the wood along to River Po near Bassignana identified as *Querco-Ulmetum minoris* by Assini (1998).

Indeed this forest type has been usually attributed in the Italian literature on a physiognomic-ecological basis to *Querco-Ulmetum* Issler 1924, described from southern Germany, with which it has in common the dominance in the tree layer of *Quercus robur* and *Ulmus minor*. The analysis of the synoptic table of the *Ulmus minor* woods at the European level demonstrates the autonomy of the oak-elm woods of the Po Plain (col. 9 in Tab. 7) from the Central European *Querco-Ulmetum* (col. 13). The presence of entities with a southern gravitation and the scarcity of *Fagetalia* justify a more appropriate inclusion of the coenosis within the *Dioscoreo-Ulmion* alliance. In particular, *Vinco-Ulmetum* differs from *Querco-Ulmetum* of Central Europe for the high frequency of *Hedera helix* and *Dioscorea communis* (absent in *Querco-Ulmetum*), and for the lack of *Fraxinus excelsior*, *Acer pseudoplatanus*, *Primula elatior* and *Stachys sylvatica*.

In this work we also addressed the issue of the presence of *Querco-Ulmetum minoris* Issler 1924 in Northern Italy. The presence of this Central European riparian floodplain association in the Po Plain was hypothesized by Hofmann (1981) at the suggestion of Pignatti, and taken up by Gentile (1981). Later, Pedrotti and Gafta (1996) listed under this name the pedunculate oak-elm woods reported by Sartori and Zucchi (1981) and Cavani et al. (1981) for Lombardy, in addition to other woods reported by Bracco et al. (1984) for Frascarolo, Lausi et al. (1978) for Friuli, and Guglielmetto Mugion and Montacchini (1993-94) for Lake Viverone (Piedmont). Various authors subsequently reported *Querco-Ulmetum* from different areas of the Po Plain, but already Assini et al. (2010) include this association among the syntaxa of doubtful presence in the area of the River Po. In the Italian interpretation manual of the 92/43/ECC Habitats Directive (Biondi et al. 2009), *Querco-Ulmetum* is taken up and attributed to the habitat 91F0.

On the basis of our analysis, the riverside oak-elm woods reported by Sartori and Zucchi (1981), Cavani et al. (1981), Bracco et al. (1984) and Assini (1998) are attributed to the new association *Vinco-Ulmetum*, while the peculiar swamp wood from Lake Viverone does not correspond to *Querco-Ulmetum* for both floristic and ecological features (see comment to *Dioscoreo-Ulmion* alliance). No relevés are available for the riverine woodlands dominated by *Ulmus minor*, *Quercus robur* and *Acer campestre* recorded from the High Friulian plain by Lausi et al. (1978). According to these authors, their treatment was strongly problematic already at that time due to their much reduced distribution and strong human-induced alteration: their classification using Central European models was tentative and can no longer be maintained based on current knowledge. A connection of these stands with *Carici albae-Fraxinetum excelsioris* described in this work from the same area is possible.

Therefore, almost all records of riverine oak-elm forests attributed to *Querco-Ulmetum* in the Italian literature were found to correspond to *Vinco-Ulmetum*, while the remaining ones are to be differently classified. As a result, the presence of *Querco-Ulmetum minoris* has not yet been demonstrated unequivocally in Italy.

Synecology: *Vinco-Ulmetum* is a riverside hardwood, meso-hygrophilous forest occurring in the Low Po Plain, found on the low river terraces near the river channel; it is not inundated during periods of normal high discharge, but it is regularly inundated during the most intense floods. It grows on mostly sandy-gravelly to sandy-silty mineral soils with a very high water table (see Cavani et al. (1981), Sartori and Zucchi (1981), Bracco et al. (1984) and Assini (1998)).

The community is found only as very reduced stands, suffering from strong fragmentation and heavy human disturbances which have affected the structural features of these woodlands. The high presence of shrubs of *Prunetalia*, along with the rather frequent reduced development of the tree layer can be correlated to human pressures on the tree component.

The coenosis shows a certain variability, which allows to distinguish two aspects: one aspect with *Viburnum lantana* on hydromorphic soils with greater quantity of *Rubus caesius* (rels. 1-17 of Tab. 9), and another aspect on deeper, more nutrient-rich soils with *Sambucus nigra*, *Solanum dulcamara*, *Corylus avellana* as well as *Fagetalia* species (*Asarum europaeum*, *Salvia glutinosa)* (rels. 18-35).

Synchorology: Piedmont and Lombardy, along the Rivers Po, Adda and Oglio (Suppl. material 1, Fig. S1); possibly to be extended also to Friuli, since in some spots along the River Tagliamento now intended for agricultural use there are frequent isolated individuals of *Quercus robur* associated with *Viburnum lantana*.

Annex I Habitat (92/43/EEC Directive): 91F0.

Ass.: *SALVIO GLUTINOSAE-QUERCETUM ROBORIS* Poldini, Vidali & Castello *ass. nov*.

Holotypus: rel. 4 of Tab. 1 in Cavani et al. 1981: 22.

Corresponding names: “Boschi igrofili a *Populus alba*” in Cavani et al. (1981).

Diagnostic species: *Populus alba*, *Neottia ovata*, *Salvia glutinosa*, *Aegonychon purpurocaeruleum* (Suppl. material 2, Tab. S1).

Structure and composition: See Cavani et al. (1981). It is an open mixed wood, with the tree layer showing a modest cover, reaching up to 40%. The dominant species is *Populus alba*, usually joined with *Quercus robur* and *Populus nigra*, and more rarely *Ulmus minor*. *Ulmus minor* and *Quercus robur* are rather abundant in the shrub layer, along with the shrubs *Crataegus monogyna*, *Corylus avellana*, *Ligustrum vulgare*, *Cornus sanguinea* and *Viburnum lantana*, while *Populus alba* shows poor vitality. The climbing species *Dioscorea communis* and *Hedera helix* are very common, accompanied by *Clematis vitalba*. The herbaceous layer is discontinuous; the most frequent species are *Salvia glutinosa*, *Asarum europaeum* s.l., *Neottia ovata* and *Primula vulgaris*.

Syntaxonomy: The association includes the stands reported as “Boschi igrofili with *Populus alba*” by Cavani et al. (1981) from the River Adda and originally classified in *Alno-Padion*. The multivariate analysis confirmed the independence of this community (Figs. 1, 2, 5), excluded affinities with woodlands of the *Dioscoreo-Populion* alliance and supported its assignment in *Dioscoreo-Ulmion* with other communities previously attributed to *Alno-Padion*

Table 9. *Vinco minoris-Ulmetum minoris ass. nov*. Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Complete linkage).

Relevé number	1	2	3	4	5	6	7	8	9*	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
Area (m²)	90	50	80	50	80	80	50	40	100	40	100	50	120	50	50	50	80	50	50	200	300	300	100	200	200	100	250	100	50	100	100	60	300	200	100	
No. of species (incl. sporadic species)	16	14	21	13	17	16	12	14	15	14	20	13	21	21	18	9	24	27	17	18	16	21	12	21	17	12	14	15	16	19	21	15	20	21	19	Fr.
Diagnostic species of the association																																				
Vinca minor L.	+	.	1	+	1	2	+	2	1	4	2	.	.	.	2	1	.	.	.	.	.	.	1	2	2	1	.	3	.	.	+	.	.	.	.	51.4
Species of *Dioscoreo-Ulmion*																																				
Dioscorea communis (L.) Caddick & Wilkin	.	1	.	2	2	+	1	+	+	.	.	1	1	.	2	.	+	.	+	.	.	.	.	+	+	.	+	1	+	1	2	2	1	+	1	65.7
Lonicera caprifolium L.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	+	+	.	.	1	2	1	2	.	25.7
Prunus spinosa L. subsp. *spinosa*	.	.	1	.	.	1	.	2	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14.3
Platanus hispanica Mill. ex Münchh.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.7
Lamium orvala L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.9
Species of *Populetalia albae* and *Alno glutinosae-Populetea*																																				
Ulmus minor Mill. subsp. *minor*	1	1	2	2	1	1	2	2	3	2	2	2	3	4	3	5	2	4	3	3	4	3	+	2	2	1	2	2	3	1	1	2	2	1	3	100.0
Rubus caesius L.	3	3	4	3	3	2	2	1	+	1	2	3	3	2	3	2	2	2	.	+	1	1	.	+	+	1	1	.	1	2	2	2	+	+	+	91.4
Quercus robur L. subsp. *robur*	2	2	2	3	3	3	2	2	2	2	2	.	.	+	.	.	+	3	2	2	3	2	2	2	3	1	2	2	+	+	1	4	2	2	2	88.6
Populus nigra L.	.	1	1	.	.	.	.	1	+	.	1	.	.	.	+	.	.	.	.	.	.	.	1	1	.	1	1	.	2	+	2	.	.	.	.	37.1
Sambucus nigra L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	2	.	+	.	.	1	+	2	+	.	+	+	1	+	37.1
Solanum dulcamara L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	+	.	+	+	+	+	1	+	28.6
Aegopodium podagraria L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	3	3	2	+	.	+	+	.	20.0
Viburnum opulus L.	2	.	+	.	2	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11.4
Brachypodium sylvaticum (Huds.) P. Beauv.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11.4
Bryonia dioica Jacq.	.	.	.	.	.	.	1	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	11.4
Silene baccifera (L.) Durande	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	+	.	.	.	.	.	.	.	.	.	+	.	.	.	14.3
Salix alba L.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	5.7
Ficaria verna Huds. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.7
Species of *Rhamno-Prunetea*																																				
Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó)	2	2	1	1	1	1	1	+	2	1	1	1	1	1	1	1	+	+	2	1	2	+	1	2	+	1	+	1	2	+	1	+	1	+	1	100.0
Ligustrum vulgare L.	1	1	2	3	1	1	1	1	2	1	1	2	2	2	+	+	+	3	3	3	2	2	2	1	1	+	1	+	.	.	.	+	+	1	2	91.4
Crataegus monogyna Jacq.	1	.	1	2	1	1	1	+	1	+	1	1	2	2	2	.	1	2	1	2	1	1	+	1	1	.	1	+	.	+	1	+	1	1	2	88.6
Hedera helix L. subsp. *helix*	.	+	1	1	1	4	4	1	2	1	4	3	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	3	3	4	3	3	57.1
Viburnum lantana L.	2	1	.	3	1	1	1	1	2	2	1	2	1	1	+	.	.	+	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	51.4
Clematis vitalba L.	1	.	1	.	2	.	.	+	1	.	1	1	.	.	.	.	.	.	3	1	.	.	.	+	+	+	+	+	+	.	+	.	.	+	.	48.6
Corylus avellana L.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	1	1	.	.	.	+	+	+	1	+	2	.	37.1
Euonymus europaeus L.	.	+	1	.	.	1	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	17.1
Acer campestre L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	2	+	.	.	.	.	.	1	.	.	.	.	14.3
Rhamnus cathartica L.	.	.	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	8.6
Rosa canina (aggr.)	.	.	+	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.6
Fraxinus ornus L. subsp. *ornus*	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.6
Lonicera xylosteum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	.	.	.	.	.	.	.	.	.	+	+	.	14.3
Species of *Fagetalia sylvaticae*																																				
Asarum europaeum L. s.l. (incl. subsp. *caucasicum* (Duch.) Soó)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	+	+	+	+	.	.	+	+	+	1	1	+	34.3
Salvia glutinosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	+	.	.	+	.	.	+	.	.	+	2	22.9
Anemonoides nemorosa (L.) Holub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.7
Pulmonaria officinalis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	5.7

Table 9. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9*	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
Area (m²)	90	50	80	50	80	80	50	40	100	40	100	50	120	50	50	50	80	50	50	200	300	300	100	200	200	100	250	100	50	100	100	60	300	200	100	
No. of species (incl. sporadic species)	16	14	21	13	17	16	12	14	15	14	20	13	21	21	18	9	24	27	17	18	16	21	12	21	17	12	14	15	16	19	21	15	20	21	19	Fr.
Hygro-nitrophilous species																																				
Galium aparine L.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	1	+	+	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	+	22.9
Alnus glutinosa (L.) Gaertn.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	+	.	.	17.1
Glechoma hederacea L.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	+	+	17.1
Urtica dioica L. s.l.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	8.6
Parietaria officinalis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	2	1	.	.	.	+	.	14.3
Other species																																				
Robinia pseudoacacia L.	.	.	.	.	.	1	.	1	+	2	1	1	1	.	.	+	.	+	1	2	1	1	+	2	+	+	+	1	.	+	.	.	+	+	.	62.9
Lonicera japonica Thunb.	.	2	.	.	1	.	.	.	.	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25.7
Viola canina L. subsp. *canina*	.	.	+	.	2	.	.	.	.	.	.	+	1	+	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22.9
Amorpha fruticosa L.	+	.	.	1	+	.	.	.	.	.	.	.	1	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17.1
Viola odorata L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	.	+	1	+	.	.	+	.	.	.	.	.	.	.	+	22.9
Symphytum officinale L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	+	.	1	17.1
Galium mollugo L.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	11.4
Limniris pseudacorus (L.) Fuss	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	11.4
Frangula alnus Mill. subsp. *alnus*	1	.	.	.	.	.	.	.	.	.	2	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.6
Salix eleagnos Scop.	1	1	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.6
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.6
Solidago gigantea Aiton	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	8.6
Equisetum arvense L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	8.6
Galeopsis pubescens Besser	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.7

(Tab. 7 and Suppl. material 2, Tab. S1). Also in this case the species of the *Dioscoreo-Ulmion* alliance *Dioscorea communis* and *Hedera helix* and of *Fagetalia* (*Primula vulgaris*, *Isopyrum thalictroides*, *Salvia glutinosa*, *Symphytum tuberosum* subsp. *angustifolium*) are well represented (Suppl. material 2, Tab. S1). We avoided considering *Populus alba* in the name of the association due to its failure in regeneration reported by the original authors. The new association is based on the original table of Cavani et al. (1981), from which however relevé number 8 is excluded.

Synecology: See Cavani et al. (1981). It is a hygrophilous riverine woodland, representing the wettest forest type after the riparian willow woodland observed in the area surveyed by these authors. It occurs on sandy-gravelly soil, with the water table always high (water at a depth of less than 1 m). It is more hygrophilous than *Vinco-Ulmetum* being found in sites closer to the water.

Catenal contacts: In contact with *Vinco-Ulmetum*.

Synchorology: Lombardy, lower course of the River Adda (Suppl. material 1, Fig. S1).

Annex I Habitat (92/43/EEC Directive): 91F0.

Willow open forests and scrubs of the class *Salicetea purpureae*

Ass.: *AMORPHO FRUTICOSAE-SALICETUM ALBAE* Poldini, Vidali, Bracco, Assini & Villani in Poldini, Vidali & Ganis 2011 (Suppl. material 3, Tab. S2)
(the holotype of *Amorpho-Salicetum albae* is designated in Poldini et al. 2011: 142, corresponding to rel. 1 of Suppl. material 3, Tab. S2 in this paper)

Pseudonyms: *Salicetum albae* sensu Auct. Ital. p.p. non Issler 1926.

Corresponding names: *Salicetum albae* Issler 1926 var. *Amorpha fruticosa* in Biondi et al. (1999).

POPULETOSUM NIGRAE Assini, Bracco, Carrea & Villani ex Poldini, Vidali & Castello *subass. nov*.

Holotypus: rel. 8 of Suppl. material 3, Tab. S2 in this paper.

Corresponding names: *Salicetum albae* Issler 1926 var. a *Populus nigra* e *Salix purpurea* in Assini et al. (2010).

VAR. *RUBUS CAESIUS* (rels. 1-14 of Suppl. material 3, Tab. S2 in this paper)

VAR. *LYTHRUM SALICARIA* (rels. 15-24 of Suppl. material 3, Tab. S2 in this paper)

URTICETOSUM DIOICAE Assini, Bracco, Carrea & Villani ex Poldini, Vidali & Castello *subass. nov*.

Holotypus: rel. 49 of Suppl. material 3, Tab. S2 in this paper.

Pseudonyms: *Salicetum albae* Issler 1926 subass. *rubetosum* sensu Assini, Bracco, Carrea & Villani 2010 non Šilc 2003.

VAR. *SAMBUCUS NIGRA* AND *CUCUBALUS BACCIFER* Assini, Bracco, Carrea & Villani 2010 (rels. 25-42 of Suppl. material 3, Tab. S2)

VAR. B*IDENS FRONDOSA* AND *PERSICARIA DUBIA* Assini, Bracco, Carrea & Villani 2010 (rels. 43-87 of Suppl. material 3, Tab. S2)

Diagnostic species of the association: *Salix alba*, *Amorpha fruticosa*, *Solidago gigantea*, *Helianthus tuberosus*.

Structure and composition: Softwood woodland, forming thin linear stands along watercourses, with the tree layer dominated by *Salix alba*, sometimes accompanied by *Populus nigra*. The shrub layer can be poorly developed to dense, but still poor in species, consisting mainly of *Rubus caesius*, *Sambucus nigra*, *Salix alba* and *Populus nigra*, sometimes accompanied by *Salix purpurea*, *S. triandra*, *Acer negundo* and *Cornus sanguinea*. The herbaceous layer is poorly developed, as result of the disruptive action of the frequent periods of high water; common elements are hygrophilous species such as *Equisetum arvense*, *Lythrum salicaria*, *Lycopus europaeus*, *Phragmites australis*, *Phalaris arundinacea*, *Persicaria hydropiper*, and hygro-nitrophilous species such as *Agrostis stolonifera*, *Galium aparine*, *Persicaria dubia*, *Ranunculus repens*, *Rumex conglomeratus*, *Urtica dioica*. Climbing vines are numerous (*Convolvolus sepium*, *Humulus lupulus*, *Clematis vitalba*, etc.). The association is definitely characterized by a strong contingent of exotic elements, such as *Amorpha fruticosa*, *Robinia pseudoacacia*, *Acer negundo*, *Sicyos angulatus*, *Bidens frondosa*, *Helianthus tuberosus*, *Solidago gigantea*.

Syntaxonomy: The riverine *Salix alba*-dominated association of the Po Plain established by Poldini et al. (2011), in which the analytic table had not been included, is here presented in more detail. In the comparison with other *Salix alba* woods at the Italian and European levels, *Amorpho-Salicetum* stands out for the transitional character between the Mediterranean and the truly Temperate communities and the high incidence of exotic elements. As already discussed by Poldini et al. (2011), when an invasive perennial exotic and/or synanthropic plant species structurally modifies a community replacing various original species, and also changes the environmental characteristics thus becoming a species that transforms the environment and builds the community (i.e. transformer and edificator species) (Pyšek et al. 2004), it is permissible to use it as a diagnostic species in the formulation of the name and characterization of the syntaxon.

The current situation of riverine *Salix alba* woodlands in Italy can be summarized as follows. The coenoses of southern Italy converge into the central-western Mediterranean alliance *Salicion pedicellatae*, *Rubo-Salicetum albae* has been established for the woodlands of central Italy, while the vicariant *Amorpho-Salicetum albae* has been described for the Po Plain area. While not excluding that other natural or near natural situations attributable to *Salicetum albae* Issler 1926 may exists in the Po Plain, its presence remains to be ascertained.

Synecology: Softwood hygrophilous forest that thrives on the river floodplain flanking the channel, frequently inundated for long periods at times of high discharge, but well-drained during low water periods, and therefore subject to significant fluctuations of the water level. It occurs on mainly sandy to silty-clayey alluvial soils (fluvisols), along the middle and lower courses of rivers in lowland and hill areas of the Po Plain.

Amorpho-Salicetum is characterized by a strong level of hemeroby, due to the interaction of two main factors: the association occurs in an area heavily affected by intense human activities (industry, agriculture) and demographic concentration, and it thrives on highly unstable, dynamic fluvial areas subject to frequent flood disturbance but also to a large nutrient supply that enhance the vulnerability of these habitats to the invasion by exotic species.

The analytic table of *Amorpho-Salicetum* (Suppl. material 3, Tab. S2) highlights the variability of the coenosis, already identified by Assini et al. (2010) and Poldini et al. (2011), which may be referable to two main aspects, here described as new subassociations, namely *populetosum nigrae* and *urticetosum dioicae*. The interpretation of the variability of the coenosis is based above all on the occurrence of woody species or ecological groups of species, as in these habitats, which are very dynamic and unstable being conditioned by strong hydrodynamics, the herbaceous species are more subject to strong fluctuations, which often interfere with primary successions (Dierschke 1996). Conversely, woody species are elements that once established tend to maintain themselves, so they are less subject to marked variations. The subassociations are related to remarkable soil variations on wide areas and correspond to the two fundamental ecologies, one still torrential and the other fluvial.

The subass. *populetosum nigrae* (rels. 1-24) corresponds to the aspect rich in *Populus nigra* (and hybrids) in which *Salix triandra* and *S. purpurea* occur as well, including the stands that seem less altered, linked to the stretches still with a torrential character. It is spread in Friuli Venezia Giulia, Emilia Romagna and Veneto, in the stretches lying in the transition between the High and Low Plain, where a braided structure of the channel still persists and there is a mineral gravel fraction in the sandy-silty matrix of the soil. This situation occurs both on the Alpine side and the Appenine one. The diagnostic species of the subass. *populetosum nigrae* are: *Populus nigra*, *Salix triandra* subsp. *triandra*, *S. purpurea*, *S. eleagnos*. Two variants are identified:

a) a variant with *Rubus caesius* (rels. 1-14), basically bound to the Alpine watercourses of NE Italy (Tagliamento);
b) a variant with *Lythrum salicaria* and *Agrostis stolonifera* and without *Rubus caesius* (rels. 15-24), on more sandy-silty soils, of the right tributaries (Apennine watercourses) of the River Po, and more rarely of the Alpine rivers (Piave).

The subass. *urticetosum dioicae* (rels. 25-87) is connected to stretches with fluvial regime, finer sediments and higher eutrophication, where various hygrophilous woody species fail. It is characterized by the rarefaction of shrub willows and the reduction of *Populus nigra*; it is found along the river reaches of the Low Plain, on sandy-silty to silty-clayey soils with strong water level fluctuation, as pointed out by the presence of *Phalaris arundinacea*, and eutrophication, as indicated by *Urtica dioica*. The diagnostic species of this subassociation are: *Urtica dioica*, *Phalaris arundinacea* subsp. *arundinacea*, *Poa trivialis*, *Convolvulus sepium*, *Limniris pseudacorus*. The subass. can be further subdivided on the basis of the water regime in two variants that correspond to those already recognized by Assini et al. (2010) which are confirmed with an enlargement of the differential entities (Suppl. material 3, Tab. S2):

a) a variant with *Sambucus nigra* and *Cucubalus baccifer* (rels. 25-42), along with *Humulus lupulus*, a little drier, still with a certain condition of naturalness, located on positive undulations of the floodplain with lower soil moisture, characterized by a reduced occurrence of ruderal and exotic species. These stands tend towards the formation of fluvial nitrophilous mantles (cfr. *Bryonio-Sambucetum*).
b) a variant with *Bidens frondosa* and *Persicaria dubia* (rels. 43-87), strongly disturbed and invaded by exotic species such as *Sicyos angulatus*, in which shrub willows disappear, *Populus nigra* becomes rare, and the tree layer is markedly depleted in species; conversely, there is an increase in frequency and cover values of *Phalaris arundinacea* as well as synantrophic species given by neophytes and hygro-nitrophilous ruderals of *Bidentetea tripartitae*, *Stellarietea mediae* and *Artemisietea vulgaris*. This is a typical aspect of the lowland stretches heavily affected by intensive human activity (with high polyhemerobic level).

Catenal contacts: It is found in slightly higher positions of the river floodplain with respect to the willow scrub *Salicetum triandrae*. It can come in contact landwards, towards higher, more sandy-gravelly sites with *Dioscoreo-Populetum nigrae*.

Synchorology: Lowlands of almost the entire Po Plain, in the Temperate oceanic and continental bioclimate variants, from upper mesotemperate to lower supratemperate thermotypes.

Annex I Habitat (92/43/EEC Directive): This *Salicion albae* vegetation includes riparian white willow woods that potentially match with the Annex I habitat 91E0* representing a more or less degraded and alien-invaded *Salix alba* habitat type in urgent need of conservation measures, although often with low possibility of restoration.

Ass.: *SALICETUM TRIANDRAE* Malcuit 1929 (Tab. 10)

Diagnostic species: in Italy *Salix triandra*.

Structure and composition: Riparian scrub or mesoforest. There may be a discontinuous tree layer dominated by *Salix alba* and *Populus nigra* and sometimes *P. alba*. The shrub layer is well developed and dense, dominated by *Salix triandra*, which may be joined by *S. purpurea* and *S. alba*; *Amorpha fruticosa* can be present with thick complexes. The herbaceous layer is discontinuous and rather poor, characterized by hygro-nitrophilous species: *Agrostis stolonifera* is often present, accompanied by *Phragmites australis* in the sites from central Italy and *Calamagrostis pseudophragmites* in those from North-Eastern Italy. The community is characterized by a high level of hemeroby (*Amorpha fruticosa*, *Bidens frondosa*, *Erigeron canadensis*,

Table 10. *Salicetum triandrae* Malcuit 1929 from different parts of Italy. Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Ward's method). Cl: species of *Salicetea purpureae*; All: species of *Salicion triandrae*.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
Altitude (m a.s.l.)	.	.	.	.	.	.	.	5	.	.	.	.	.	.	60	21	.	.	190	50	35	.	.	.	15	.	.	5	.	.	.	.	.	
No. of species (incl. sporadic species)	12	10	10	10	16	10	9	13	10	14	8	10	11	9	11	30	30	17	13	16	30	17	24	21	28	7	14	13	9	21	25	15	8	Fr.
Diagnostic species of association in Italy																																		
Cl, All *Salix triandra* L. subsp. *triandra*	5	5	4	4	3	3	4	5	3	4	4	5	4	5	4	3	3	3	5	5	2	3	2	4	3	1	4	4	3	3	2	2	2	100.0
Species of *Salicetea purpureae* and *Salicion triandrae*																																		
Salix purpurea L. s.l.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	2	.	.	+	+	1	+	1	1	+	5	1	1	.	.	.	.	.	39.4
Salix eleagnos Scop.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	6.1
Other species																																		
Salix alba L. (incl. *S.* ×*fragilis* L.)	1	1	1	1	3	3	2	1	2	1	3	2	2	1	.	3	2	2	+	1	2	2	2	2	2	+	1	1	2	1	1	.	.	90.9
Xanthium italicum Moretti	+	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	2	2	1	+	+	1	+	+	1	1	.	.	.	1	1	.	.	54.5
Agrostis stolonifera L.	+	+	+	+	.	.	.	.	.	.	2	+	.	+	.	.	2	2	2	2	2	2	+	.	+	.	+	+	2	.	.	.	.	54.5
Populus nigra L. (incl. *P. xcanadensis* Moench)	.	.	.	.	.	.	1	.	.	1	2	+	1	.	.	.	+	+	.	+	+	.	1	1	1	1	.	.	1	2	+	2	3	54.5
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	1	1	+	+	+	+	.	.	1	+	.	.	1	.	1	.	.	.	1	+	.	.	1	.	+	.	.	.	1	.	.	.	.	45.5
Persicaria lapathifolia (L.) Delarbre	.	.	+	+	+	.	.	.	.	.	.	.	.	.	r	2	+	+	+	1	.	+	.	.	.	.	.	.	.	+	1	.	.	36.4
Lycopus europaeus L.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.	+	+	1	1	1	.	+	.	+	.	.	.	+	.	.	.	.	33.3
Juncus articulatus L. subsp. *articulatus*	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	1	.	+	.	+	.	.	.	2	+	.	30.3
Lythrum salicaria L.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	+	+	+	1	+	.	.	.	+	+	.	.	.	.	+	.	.	30.3
Bidens frondosa L.	.	.	.	.	+	+	+	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	.	1	+	.	.	27.3
Paspalum distichum L.	r	+	+	+	+	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24.2
Symphyotrichum squamatum (Spreng.) G.L.Nesom	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	1	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	24.2
Bidens tripartita L. s.l.	r	.	.	.	.	.	.	.	1	+	.	.	.	.	r	1	.	.	.	.	.	1	+	.	.	.	.	.	.	+	.	.	.	24.2
Equisetum arvense L.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	+	2	.	.	.	.	1	.	.	.	+	.	.	.	.	+	1	.	.	24.2
Pulicaria dysenterica (L.) Bernh.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	+	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	24.2
Amorpha fruticosa L.	.	.	.	.	.	.	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	+	1	.	2	2	2	.	.	.	.	24.2
Echinochloa crus-galli (L.) P.Beauv. subsp. *crus-galli*	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	+	.	.	.	.	1	3	.	.	.	.	.	.	+	1	1	.	24.2
Helianthus tuberosus L.	.	.	.	.	.	.	.	.	.	.	+	.	2	1	+	3	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	21.2
Rubus caesius L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	+	1	1	.	.	.	.	.	1	1	.	.	.	.	.	21.2
Cyperus fuscus L.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1	.	18.2
Erigeron canadensis L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	r	+	r	.	18.2
Galega officinalis L.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	+	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	18.2
Equisetum ramosissimum Desf.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	18.2
Daucus carota L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	+	+	+	.	.	.	+	.	.	.	18.2
Convolvulus sepium L.	.	.	.	.	.	.	.	.	.	.	1	.	1	1	+	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	18.2
Phalaris arundinacea L. subsp. *arundinacea*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	1	1	.	.	.	.	.	15.2
Artemisia vulgaris L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	1	+	.	+	.	15.2
Calamagrostis pseudophragmites (Haller f.) Koeler subsp. *pseudophragmites*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	1	.	.	+	.	.	15.2
Typha latifolia L.	1	1	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	15.2
Lotus corniculatus L.	.	.	+	+	r	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15.2
Artemisia verlotiorum Lamotte	.	.	r	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12.1
Alisma plantago-aquatica L.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	12.1
Tussilago farfara L.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	12.1
Rorippa palustris (L.) Besser	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	12.1

Table 10. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
Altitude (m a.s.l.)	.	.	.	.	.	.	.	5	.	.	.	.	.	.	60	21	.	.	190	50	35	.	.	.	15	.	.	5	.	.	.	.	.	
No. of species (incl. sporadic species)	12	10	10	10	16	10	9	13	10	14	8	10	11	9	11	30	30	17	13	16	30	17	24	21	28	7	14	13	9	21	25	15	8	Fr.
Dactylis glomerata L. s.l.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	12.1
Ranunculus repens L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	12.1
Populus alba L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	1	.	.	r	.	.	.	.	.	.	.	.	.	12.1
Schoenoplectus tabernaemontani (C.C.Gmel.) Palla	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9.1
Erigeron annuus (L.) Desf.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	9.1
Atriplex prostrata Boucher ex DC.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	9.1
Dittrichia viscosa (L.) Greuter subsp. *viscosa*	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	9.1
Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	9.1
Poa trivialis L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	9.1
Urtica dioica L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	9.1
Plantago major L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	9.1
Buddleja davidii Franch.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	+	.	.	.	.	.	9.1
Cyperus longus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	9.1
Ambrosia artemisiifolia L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	9.1
Eragrostis pectinacea (Michx.) Nees	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	1	.	9.1
Agrostis gigantea Roth subsp. *gigantea*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	9.1
Panicum capillare L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	1	.	.	9.1

Helianthus tuberosus, *Symphyotrichum squamatum*, *Xanthium italicum*, etc.).

Syntaxonomy: The relevés of *Salicetum triandrae* s.l. from Italy were compared by multivariate analysis with those of similar formations from various areas of Europe. The analysis did not allow to detect particular variations within the relevés at national level (Tab. 10), which can therefore be treated as one single association. Not even the comparison at the European level (Tab. 11), recognizes particular features in the Italian stands to justify their inclusion in a distinct, new association. Constant elements in common with the other European *Salix triandra* scrubs are *Convolvolus sepium* and *Phalaris arundinacea*, sub-hygrophilous companion species which in the Italian relevés reach much lower values of presence compared to the other European communities.

Salicetum triandrae from Italy (col. 4 in Tab. 11) differs from the other willow scrubs of Europe for the following three main characters: 1) absence of *Salix viminalis* for biogeographical reasons; 2) high presence of *Populus nigra* (incl. hybrids) and in subordinate way of *Populus alba*, which gives the vegetation stands a southern character; 3) large presence of *Xanthium italicum*, invasive neophyte widely spread in Italian river habitats, especially on silty sediments. Besides riparian woodlands, this entity has already been used to describe other hygrophilous coenoses (see e.g. Markovic (1981)) such as *Polygono lapathifolii-Xanthietum italici* and *Xanthietum italici*.

The statistical analysis (Figs. 7, 8) highlights the peculiar position of the communities of Serbia and Croatia. The relevés from Serbia are those of *Salicetum albo-triandrae* Slavnić 1952, described from Vojvodina and considered by Horvat et al. (1974) a synonym of *Salicetum triandro-viminalis* Tüxen (1931) 1951, that is *Salicetum triandrae*: they show a floristic composition that is different from the other coenoses, revealing an ambiguous situation between fluvial and swamp systems.

Synecology: It is a riverine, pioneer, dense tall scrub community, which constitutes the first front of woody riparian vegetation towards the water on loamy sediments, thriving in the lowest areas of the floodplain close to the river channel that are regularly inundated for long periods at high water. It occurs in the lower courses of rivers and is linked to slow-flowing water that allows the sedimentation of fine deposits. It has been strongly compromised by human interventions of flow regulation and use of water resources, and has now become a rare vegetation with fragmentary presence.

Catenal contacts: In contact with *Salix alba* woodlands (*Salicion albae*), which are found on higher sites of the river floodplain.

Synchorology: North and Central Italy up to Abruzzo (Biondi and Blasi 2015).

Annex I Habitat (92/43/EEC Directive): -. Although it is not included in the Annex I of the Habitats Directive, in Italy this community is by now rare and often reduced to linear fragments, more or less disturbed by human actions and use of water resources: it generally shows an overall poor conservation status.

Submediterranean xero-thermophilous *Fraxinus excelsior* forests of the alliance *Ostryo carpinifoliae-Tilion platyphylli* (class *Querco-Fagetea*)

Ass.: *CARICI ALBAE-FRAXINETUM EXCELSIORIS* Poldini, Vidali & Castello *ass. nov*. (Tab. 12)

Holotypus: rel. 4 of Tab. 12 in this paper.

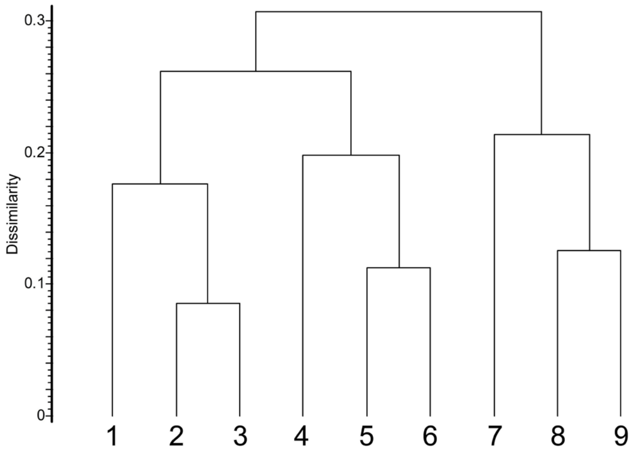

Figure 7. Cluster analysis (frequency data, Similarity ratio, Ward's method) of synthetic tables of *Salicetum triandrae* from different parts of Europe included in Tab. 11. Labels of synthetic tables as in Tab. 11.

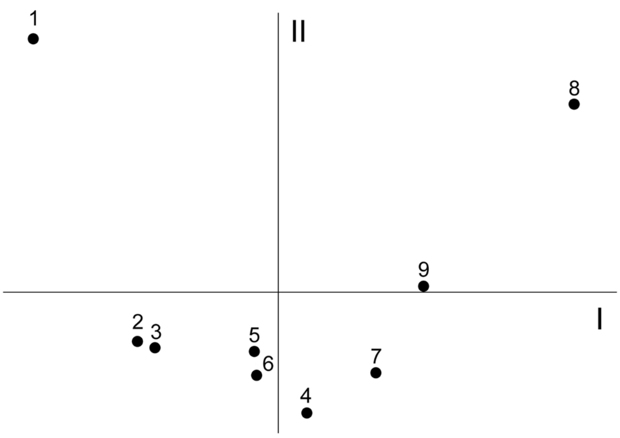

Figure 8. PCA of synthetic tables of *Salicetum triandrae* from different parts of Europe included in Tab. 11. (First component: 31.13 % of total variance, second component: 21.89 %). Labels of synthetic tables as in Tab. 11.

Diagnostic species: *Carex alba*, *Berberis vulgaris*, *Cephalanthera longifolia*, *Neottia nidus-avis*, *Pinus sylvestris*.

Structure and composition: Macro- to mesoforests with the tree layer dominated by *Fraxinus excelsior*, accompanied by *Tilia cordata*, *Acer pseudoplatanus* and *Pinus sylvestris*, sometimes *Populus nigra* or *Picea abies*. The shrub layer is rich in species, among which are *Cornus sanguinea* subsp. *hungarica*, *Corylus avellana*, *Crataegus monogyna*, *Ligustrum vulgare*, *Lonicera xylosteum* and *Rubus caesius*, constantly accompanied by *Berberis vulgaris*; *Hedera helix* is common as well. The herbaceous layer is characterized by the high cover values of *Carex alba*; common species are *Anemonoides trifolia*, *Brachypodium sylvaticum*, *Vinca minor* and *Viola reichenbachiana*.

Syntaxonomy: The assignment to the *Ostryo-Tilion* alliance, which includes xero-thermophilous mixed deciduous forests of south-eastern Europe growing in valley bottoms and ravines mainly in the sectors with submediterranean climate, is given by the presence of species such as *Fraxinus excelsior*, *Acer pseudoplatanus*, *Tilia platyphyllos*, *Ulmus glabra*, *Aruncus dioicus*, as well as a large series of thermophilous elements, such as *Hedera helix*, *Cornus mas*, *C. sanguinea* subsp. *hungarica*, *Dioscorea communis*, *Ligustrum vulgare*. *Fagetalia* entities are well represented. This is the least xero-thermophilous association within the *Ostryo-Tilion* alliance, differing in the greater presence of meso-hygrophilous species, such as *Aegopodium podagraria*, *Brachypodium sylvaticum*, *Rubus caesius*, *Populus nigra* and some elements of *Alnion incanae*.

Synecology: Xero-thermophilous alluvial *Fraxinus excelsior* forest related to river systems that occur on outer, stabilized fluvial terraces prone to extreme flood events in river stretches with a torrential character. It represents the outermost expression of ravine forests on fluvisols along torrential rivers at the their opening into the lowlands and the High Friulian Plain, on alluvial coarse-grained alkaline deposits.

Carici-Fraxinetum excelsioris is mainly found in the upper course of the River Tagliamento, in the stretch that flows through the wider part of the Tagliamento Valley lying at lower elevations (below 400 m a.s.l.). It grows on the gravelly parts of the outer terraces, on coarse-textured brunified soils with a thin layer of sand. Abundant *Pinus sylvestris* can be observed in some sites lying in lower positions along the River Tagliamento and its tributary the stream But; this could indicate that this woodland is the result of an evolution of the *Alno incanae-Pinetum sylvestris* floodplain forest of river islands, possibly favoured by river regulation interventions.

Other examples of colonization of outer, marginal parts of river valleys with a torrential character by forests dominated by noble ravine trees with *Carex alba* are represented by *Carici albae-Carpinetum betuli*, a pioneer woodland described from Slovenia on alluvial young terraces of the upper River Nadiža (Natisone) (Čušin 2002), and *Carici albae-Tilietum cordatae*, described from Germany and reported from other areas of Central Europe (e.g. France, Germany, Austria, Slovenia, Italy). The latter association

Table 11. Simplified synoptic table of *Salicetum triandrae* from different parts of Europe. Columns are arranged according to cluster analysis of Fig. 7. In columns 8 and 9 the original data expressed as frequency classes have been substituted by the corresponding average % values of the classes. 1: France (orig. Tab. 27 by Géhu 1961); 2: Czech Republic (orig. Tab. 2, col. 1 by Neuhäuslová et al. 2013); 3: Germany (orig. Tab. 241, col. 4 by Seibert and Conrad 1992); 4: Italy (Tab. 10 in this paper); 5: Slovenia (orig. Tab. 3 by Šilc 2003); 6: Austria (orig. Tab. 2, col. 1 by Karner 2007); 7: Croatia (Vukelić et al. 1999 - 1 rel.; Rauš 1976 - 3 rels.); 8: Serbia, Vojvodina (orig. Tab. 58, col. 1 sub *Salicetum albo-triandrae* Slavnić 1952 by Slavnić 1952 in Horvat et al. 1974); 9: Serbia, Belgrade (orig. Tab. 58, col. 2 sub *Salicetum albo-triandrae* Slavnić 1952 by Gajić 1954 in Horvat et al. 1974).

Number of column	1	2	3	4	5	6	7	8	9
Number of relevés	5	40	104	33	35	83	4	9	7
Species of *Salicetea purpureae*									
Salix triandra L. subsp. *triandra*	80.0	88.0	74.0	100.0	88.6	93.0	100.0	70.0	70.0
Salix purpurea L. s.l.	20.0	20.0	76.0	39.4	17.1	19.0	.	50.0	10.0
Salix eleagnos Scop.	.	3.0	3.0	6.1	.	.	.	.	.
Species of *Salicion triandrae* and *Salicetum triandrae*									
Salix viminalis L.	80.0	70.0	94.0	.	11.4	28.0	.	50.0	.
Salix euxina I.V. Belyaeva	.	60.0	.	.	.	.	.	.	.
Other species									
Salix alba L.	100.0	15.0	41.0	90.9	.	15.0	75.0	90.0	90.0
Solanum dulcamara L.	40.0	25.0	11.0	.	88.6	36.0	100.0	90.0	50.0
Convolvulus sepium L.	80.0	53.0	48.0	18.2	60.0	8.0	50.0	30.0	50.0
Phalaris arundinacea L. subsp. *arundinacea*	60.0	70.0	78.0	15.2	91.4	83.0	.	.	30.0
Poa trivialis L.	40.0	60.0	.	9.1	14.3	19.0	.	30.0	50.0
Rubus caesius L.	80.0	15.0	38.0	21.2	14.3	28.0	75.0	50.0	70.0
Ranunculus repens L.	80.0	35.0	31.0	12.1	48.6	33.0	.	50.0	30.0
Lythrum salicaria L.	40.0	3.0	.	30.3	71.4	43.0	.	50.0	50.0
Galium palustre L. s.l.	40.0	13.0	.	.	54.3	27.0	100.0	70.0	30.0
Limniris pseudacorus (L.) Fuss	40.0	5.0	.	.	5.7	39.0	75.0	50.0	30.0
Rumex conglomeratus Murray	40.0	.	.	.	2.9	.	.	30.0	10.0
Salix ×fragilis L.	40.0	3.0	29.0	.	.	4.0	.	50.0	50.0
Urtica dioica L. s.l.	100.0	93.0	88.0	9.1	94.3	47.0	50.0	50.0	.
Glechoma hederacea L.	40.0	40.0	1.0	.	17.1	10.0	.	30.0	.
Angelica sylvestris L.	40.0	20.0	46.0	3.0	14.3	6.0	.	30.0	.
Persicaria hydropiper (L.) Delarbre	60.0	8.0	.	.	71.4	24.0	.	30.0	.
Scrophularia umbrosa Dumort.	40.0	.	.	.	8.6	2.0	.	50.0	.
Viburnum opulus L.	60.0	.	5.0	.	.	1.0	.	50.0	.
Caltha palustris L.	40.0	.	.	.	2.9	1.0	.	50.0	.
Scrophularia nodosa L.	.	30.0	2.0	.	14.3	4.0	.	30.0	.
Humulus lupulus L.	.	28.0	36.0	3.0	14.3	7.0	75.0	30.0	.
Symphytum officinale L.	.	43.0	37.0	.	5.7	24.0	.	30.0	.
Lycopus europaeus L.	.	13.0	4.0	33.3	11.4	17.0	.	70.0	50.0
Lysimachia nummularia L.	.	13.0	4.0	.	14.3	12.0	.	90.0	30.0
Poa palustris L.	.	23.0	13.0	.	2.9	24.0	.	70.0	50.0
Galium aparine L.	100.0	70.0	39.0	.	8.6	8.0	.	.	.
Myosotis scorpioides L.	20.0	18.0	.	.	40.0	30.0	.	.	.
Galeopsis tetrahit L.	40.0	28.0	13.0	3.0	.	.	.	.	.
Heracleum sphondylium L.	20.0	33.0	10.0	.	.	2.0	.	.	.
Filipendula ulmaria (L.) Maxim.	80.0	30.0	43.0	.	2.9	1.0	.	.	.
Silene dioica (L.) Clairv.	60.0	3.0	17.0	.	.	1.0	.	.	.
Salix cinerea L.	80.0	.	3.0	.	20.0	7.0	.	.	.
Sambucus nigra L.	40.0	28.0	14.0	.	2.9	5.0	.	.	.
Phragmites australis (Cav.) Trin. ex Steud. s.l.	20.0	.	20.0	45.5	5.7	27.0	.	.	.
Alliaria petiolata (M.Bieb.) Cavara & Grande	60.0	18.0	7.0	.	17.1	2.0	.	.	.
Dactylis glomerata L. s.l.	20.0	25.0	9.0	12.1	2.9	4.0	.	.	.
Agrostis stolonifera L.	.	5.0	25.0	54.5	80.0	35.0	.	.	.
Aegopodium podagraria L.	.	48.0	16.0	.	8.6	2.0	.	.	.
Lamium maculatum L.	.	40.0	27.0	.	22.9	6.0	.	.	.
Rumex obtusifolius L.	.	30.0	30.0	.	5.7	27.0	.	.	.
Stellaria aquatica (L.) Scop.	.	28.0	21.0	.	2.9	11.0	.	.	.
Elymus caninus (L.) L.	20.0	33.0	9.0	.	.	.	.	.	.
Cirsium oleraceum (L.) Scop.	.	28.0	38.0	.	5.7	.	.	.	.
Persicaria lapathifolia (L.) Delarbre	.	.	15.0	36.4	2.9	12.0	.	30.0	.
Mentha aquatica L.	.	.	.	3.0	17.1	5.0	.	30.0	.
Alisma plantago-aquatica L.	.	.	.	12.1	42.9	.	.	50.0	10.0
Bidens tripartita L. s.l.	.	.	.	24.2	51.4	.	.	70.0	30.0
Populus nigra L.	.	.	2.0	54.5	.	7.0	.	30.0	30.0
Rorippa amphibia (L.) Besser	.	8.0	.	.	34.3	41.0	.	50.0	10.0
Rorippa sylvestris (L.) Besser	.	.	.	6.1	51.4	22.0	.	70.0	70.0

Table 11. Continuation.

Number of column	1	2	3	4	5	6	7	8	9
Number of relevés	5	40	104	33	35	83	4	9	7
Amorpha fruticosa L.	.	.	.	24.2	.	.	.	50.0	50.0
Echinochloa crus-galli (L.) P.Beauv	.	.	.	24.2	5.7	.	25.0	50.0	.
Stachys palustris L.	.	8.0	2.0	.	.	19.0	50.0	70.0	30.0
Valeriana officinalis L. (incl. subsp. *procurrens* (Wallr.) Soó)	100.0	.	2.0	.	.	5.0	.	.	.
Crataegus laevigata (Poir.) DC.	80.0	.	.	.	.	.	.	.	.
Alopecurus pratensis L.	60.0	10.0	.	.	.	1.0	.	.	.
Salix caprea L.	60.0	.	.	.	.	.	.	.	.
Rosa canina L.	60.0	.	.	.	.	.	.	.	.
Rubus idaeus L.	40.0	8.0	.	.	.	.	.	.	.
Epilobium hirsutum L.	40.0	.	.	3.0	.	.	.	.	.
Arrhenatherum elatius (L.) P.Beauv. ex J.Presl & C.Presl	40.0	.	.	.	.	.	.	.	.
Lychnis flos-cuculi L.	40.0	.	.	.	.	.	.	.	.
Xanthium italicum Moretti	.	.	.	54.5	.	.	.	.	.
Juncus articulatus L.	.	.	.	30.3	.	6.0	.	.	.
Populus alba L.	.	.	.	12.1	.	2.0	.	.	.
Echinocystis lobata (Michx.) Torr. & A.Gray	.	.	.	.	62.9	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	3.0	45.7	.	.	.	.
Carex elata All.	.	.	.	.	.	.	100.0	.	.
Calamagrostis epigejos (L.) Roth	.	.	.	.	.	4.0	75.0	.	.
Epilobium palustre L.	.	.	.	.	.	.	50.0	.	.
Molinia caerulea (L.) Moench	.	.	.	.	.	.	50.0	.	.
Cirsium palustre (L.) Scop.	.	.	.	.	.	.	25.0	.	.
Crepis paludosa (L.) Moench	.	.	.	.	.	.	25.0	.	.
Poa nemoralis L.	.	5.0	.	.	.	.	25.0	.	.
Scutellaria galericulata L.	.	.	.	.	8.6	5.0	50.0	70.0	.
Rumex hydrolapathum Huds.	.	.	.	.	.	.	50.0	50.0	.
Carex pendula Huds.	.	.	.	3.0	.	.	.	30.0	.
Erigeron annuus (L.) Desf.	.	.	.	9.1	.	.	.	30.0	.
Aristolochia clematitis L.	.	.	.	.	8.6	.	.	30.0	.
Frangula alnus Mill.	.	.	1.0	.	.	.	.	90.0	30.0
Plantago major L.	.	.	1.0	9.1	14.3	.	.	70.0	30.0
Potentilla reptans L.	.	.	.	3.0	.	.	.	70.0	30.0
Euphorbia palustris L.	.	.	.	.	.	.	.	50.0	30.0
Sium latifolium L.	.	.	.	.	.	.	.	50.0	30.0
Carex vulpina L.	.	.	.	.	.	.	.	30.0	30.0
Inula britannica L.	.	.	.	.	.	.	.	30.0	30.0
Ulmus laevis Pall.	.	.	.	.	.	.	.	30.0	30.0
Crataegus nigra Waldst. & Kit.	.	.	.	.	.	.	.	50.0	.
Silene baccifera (L.) Durande	.	13.0	.	.	.	.	.	30.0	.
Crataegus pentagyna Waldst. & Kit. ex Willd.	.	.	.	.	.	.	.	30.0	.
Fraxinus angustifolia Vahl	.	.	.	.	.	.	.	30.0	.
Senecio nemorensis L.	.	.	.	.	.	.	.	30.0	.
Ulmus minor Mill.	.	.	.	.	.	.	.	30.0	.
Vitis vinifera L.	.	.	.	.	.	.	.	30.0	.
Carex hirta L.	.	.	.	.	.	.	.	.	50.0
Equisetum palustre L.	.	.	.	3.0	.	5.0	.	.	30.0
Leucojum aestivum L.	.	.	.	.	.	.	.	.	30.0
Rumex sanguineus L.	.	.	.	.	.	.	.	.	30.0

has a still controversial syntaxonomic position: it is found both in ravines on steep, sunny slopes and in rarely flooded, relatively dry fluvial areas, and is placed by some authors in *Carpinion betuli* (e.g. Müller 1992; INPN 2019) and by others in *Alnion incanae* (Willner 2007). Assini (2011b) reports meso-thermophilous woods referred to as "aggruppamento a *Tilia cordata* e *Carex alba*" and classified within *Tilio-Acerion* from Lombardy on south-facing slopes at elevations between 650 and 735 m a.s.l. Assini and Verde (2007), quoting Andreis et al. (2002), list *Carici albae-Tilietum cordatae* for Lombardy. Schubert et al. (2001) cite this association from steep slopes exposed to the south of the Kaiserstühl, but also from gravelly fluvial terraces in the upper Rhine and in the eastern part of Lake Constance, classifying it in *Carpinion betuli*.

The new association would represent an ecological convergence south of the Alps of *Carici-Tilietum cordatae* of Central Europe. This would be a further confirmation of how ravine forests can also colonize gravelly alluvial terraces of watercourses in montane-hilly areas, expanding the ecological definition of the *Ostryo-Tilion* and *Tilio-Acerion*/*Fraxino excelsioris-Acerion pseudoplatani* alliances.

Table 12. *Carici albae-Fraxinetum excelsioris ass. nov.* (rels. 1-5) and *Veratro nigri-Fraxinetum excelsioris* (rels. 6-9). Relevés are arranged according to cluster analysis (cover data, Similarity ratio, Complete linkage).

Relevé number	1	2	3	4*	5	6	7	8	9		
Altitude (m a.s.l.)	400	340	361	250	248	31	32	32	40		
Area (m²)	200	200	250	200	300	200	200	250	200		
No. of species (incl. sporadic species)	62	52	49	28	22	31	32	39	27	Fr.	Fr.
	Carici albae-Fraxinetum excelsioris					***Veratro nigri-Fraxinetum excelsioris***					
Differential species of *Carici albae-Fraxinetum excelsioris*											
Carex alba Scop.	4	2	3	3	3	.	.	.	.	100.0	-
Berberis vulgaris L.	+	+	+	+	+	.	.	.	.	100.0	-
Cephalanthera longifolia (L.) Fritsch	+	.	.	+	+	.	.	.	.	60.0	-
Neottia nidus-avis (L.) Rich.	+	.	+	+	.	.	.	.	.	60.0	-
Pinus sylvestris L.	4	3	1	.	.	.	.	.	.	60.0	-
Differential species of *Veratro nigri-Fraxinetum excelsioris*											
Loncomelos pyrenaicus (L.) L.D.Hrouda	.	.	.	.	.	+	+	+	+	-	100.0
Ruscus aculeatus L.	+	.	.	.	.	.	+	+	.	20.0	50.0
Characteristic and differential species of *Ostryo-Tilion*											
Species of ravine woods											
Fraxinus excelsior L. subsp. *excelsior*	2	2	1	3	3	3	3	3	2	100.0	100.0
Lonicera xylosteum L.	2	2	1	1	1	.	.	.	.	100.0	-
Ulmus glabra Huds.	+	.	+	.	.	+	.	+	1	40.0	75.0
Acer pseudoplatanus L.	1	+	+	.	+	.	.	.	.	80.0	-
Aruncus dioicus (Walter) Fernald	.	.	+	.	+	.	.	.	.	40.0	-
Tilia platyphyllos Scop. subsp. *platyphyllos*	.	+	.	.	.	.	.	+	.	20.0	25.0
Paris quadrifolia L.	.	.	+	.	.	.	.	.	.	20.0	-
Thermophilous species of *Ostryo-Tilion*											
Hedera helix L. subsp. *helix*	2	1	1	1	+	1	+	2	1	100.0	100.0
Crataegus monogyna Jacq.	+	+	1	1	2	1	+	2	1	100.0	100.0
Ligustrum vulgare L.	+	+	2	+	1	1	+	1	1	100.0	100.0
Tilia cordata Mill.	1	.	+	3	4	1	1	2	1	80.0	100.0
Cornus sanguinea L. subsp. *hungarica* (Kárpáti) Soó	2	2	2	.	.	+	+	1	2	60.0	100.0
Euonymus europaeus L.	+	.	+	+	+	.	.	+	+	80.0	50.0
Primula vulgaris Huds. subsp. *vulgaris*	+	+	.	.	+	1	+	.	.	60.0	50.0
Cornus mas L.	+	.	.	1	.	+	+	.	.	40.0	50.0
Acer campestre L.	.	+	.	.	.	1	+	1	+	20.0	100.0
Vinca minor L.	1	1	2	.	.	.	.	1	.	60.0	25.0
Lamium orvala L.	+	.	+	.	.	+	+	+	.	40.0	75.0
Dioscorea communis (L.) Caddick & Wilkin	1	.	.	.	.	1	+	1	.	20.0	75.0
Brachypodium rupestre (Host) Roem. & Schult.	.	+	.	.	.	1	.	.	+	20.0	50.0
Clematis vitalba L.	.	+	.	+	+	.	.	+	.	60.0	25.0
Hepatica nobilis Mill.	1	1	.	+	.	.	.	.	.	60.0	-
Emerus major Mill. s.l.	+	+	.	.	.	.	.	.	.	40.0	-
Ostrya carpinifolia Scop.	+	.	.	1	.	.	.	.	.	40.0	-
Convallaria majalis L.	.	+	+	.	.	.	.	.	.	40.0	-
Fraxinus ornus L. subsp. *ornus*	.	.	.	+	.	.	.	1	1	20.0	50.0
Species of *Fagetalia*											
Brachypodium sylvaticum (Huds.) P.Beauv.	+	+	+	+	.	3	+	2	+	80.0	100.0
Viola reichenbachiana Jord. ex Boreau (incl. *V. riviniana* Rchb. subsp. *riviniana*)	+	+	+	+	+	+	+	+	.	100.0	75.0
Anemonoides trifolia (L.) Holub subsp. *trifolia*	2	1	+	1	+	.	.	2	.	100.0	25.0
Daphne mezereum L.	+	.	+	+	.	.	.	.	.	60.0	-
Ajuga reptans L.	+	+	.	.	+	.	.	.	.	60.0	-
Euphorbia amygdaloides L.	1	+	+	.	.	.	.	.	.	60.0	-
Salvia glutinosa L.	+	+	1	.	.	.	.	.	.	60.0	-
Prunus avium (L.) L.	+	+	.	.	.	.	1	.	.	40.0	25.0
Melica nutans L.	1	1	.	.	.	.	.	.	.	40.0	-
Euphorbia dulcis L.	+	+	.	.	.	.	.	.	.	40.0	-
Neottia ovata (L.) Bluff & Fingerh.	+	+	.	.	.	.	.	.	.	40.0	-
Polygonatum multiflorum (L.) All.	.	.	+	.	.	+	+	+	.	20.0	75.0
Lonicera caprifolium L.	.	.	.	.	+	1	2	+	.	20.0	75.0
Carpinus betulus L.	1	.	.	.	.	.	.	+	.	20.0	25.0
Asarum europaeum L. subsp. *caucasicum* (Duch.) Soó	.	.	1	.	.	.	.	+	.	20.0	25.0
Carex sylvatica Huds.	.	.	+	.	.	.	.	+	.	20.0	25.0
Allium ursinum L.	.	.	.	.	.	2	4	3	1	-	100.0

Table 12. Continuation.

Relevé number	1	2	3	4*	5	6	7	8	9		
Altitude (m a.s.l.)	400	340	361	250	248	31	32	32	40		
Area (m²)	200	200	250	200	300	200	200	250	200		
No. of species (incl. sporadic species)	62	52	49	28	22	31	32	39	27	Fr.	Fr.
	Carici albae-Fraxinetum excelsioris					***Veratro nigri-Fraxinetum excelsioris***					
Hygrophilous species											
Rubus caesius L.	1	2	2	+	+	2	1	+	3	100.0	100.0
Populus nigra L. (incl. *P. ×canadensis* Moench)	.	.	.	2	.	.	2	+	1	20.0	75.0
Juglans regia L.	+	.	.	.	.	+	+	.	+	20.0	75.0
Tommasinia altissima (Mill.) Reduron	+	+	.	.	.	.	.	.	.	40.0	-
Viburnum opulus L.	+	.	+	.	.	.	.	.	.	40.0	-
Fraxinus angustifolia Vahl subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso	.	.	.	.	.	1	1	1	1	-	100.0
Salix eleagnos Scop.	.	.	.	.	.	+	.	.	1	-	50.0
Ulmus minor Mill. subsp. *minor*	.	.	.	.	.	.	2	+	.	-	50.0
Other species											
Corylus avellana L.	2	3	2	1	+	2	2	+	.	100.0	75.0
Aegopodium podagraria L.	+	1	1	.	.	+	+	+	+	60.0	100.0
Picea abies (L.) H.Karst.	1	1	3	+	.	.	.	.	.	80.0	-
Rhamnus cathartica L.	+	+	+	.	.	+	.	+	.	60.0	50.0
Viburnum lantana L.	+	+	+	.	.	.	.	+	.	60.0	25.0
Colchicum autumnale L.	1	.	.	.	.	+	+	.	.	20.0	50.0
Cruciata glabra (L.) C.Bauhin ex Opiz	+	+	.	.	.	.	.	.	.	40.0	-
Fragaria vesca L. subsp. *vesca*	+	+	.	.	.	.	.	.	.	40.0	-
Hieracium murorum L.	+	+	.	.	.	.	.	.	.	40.0	-
Lilium bulbiferum L. subsp. *bulbiferum*	+	.	+	.	.	.	.	.	.	40.0	-
Oxalis acetosella L.	.	+	+	.	.	.	.	.	.	40.0	-
Galium album Mill. subsp. *album*	.	+	.	.	.	.	.	.	+	20.0	25.0
Heracleum sphondylium L. subsp. *sphondylium*	.	.	.	.	.	+	+	+	.	-	75.0
Parietaria officinalis L.	.	.	.	.	.	.	+	+	+	-	75.0
Geum urbanum L.	.	.	.	.	.	.	+	+	+	-	75.0
Robinia pseudoacacia L.	.	.	.	.	.	+	.	.	1	-	50.0
Alliaria petiolata (M.Bieb.) Cavara & Grande	.	.	.	.	.	.	.	+	+	-	50.0

Synchorology: Upper and middle reaches with torrential character of the River Tagliamento at its opening into the lowlands and the High Plain and lower course of its montane tributaries (stream But) (Friuli Venezia Giulia) (Suppl. material 1, Fig. S1).

Annex I Habitat (92/43/EEC Directive): From a formal syntaxonomic point of view this woodland would be part of 9180* - *Tilio-Acerion* forests of slopes, screes and ravines. From an ecological point of view this is a riverine, mixed forest dominated by hardwood, "noble" trees growing on alluvial recent deposits. It is therefore attributed to 91F0.

Ass.: *VERATRO NIGRI-FRAXINETUM EXCELSIORIS* Dakskobler 2007 (Tab. 12)

Diagnostic species: *Fraxinus excelsior* subsp. *excelsior*, *F. ornus* subsp. *ornus*, *Tilia cordata*, *T. platyphyllos* subsp. *platyphyllos*, *Ostrya carpinifolia*, *Veratrum nigrum*, *Ruscus aculeatus*; geographical differential species: *Anemonoides trifolia* subsp. *trifolia*, *Geranium nodosum*, *Aconitum angustifolium* (Dakskobler 2007).

Structure and composition: The tree layer is dominated by *Fraxinus excelsior* accompanied by *Tilia cordata*, *Fraxinus angustifolia* subsp. *oxycarpa*, *Acer campestre* and sometimes by *Ulmus glabra*, *Populus nigra*, *Fraxinus ornus* and *Robinia pseudoacacia*. The shrub layer includes many species: common are *Cornus sanguinea* subsp. *hungarica*, *Crataegus monogyna*, *Ligustrum vulgare*, *Rubus caesius*, along with the thermophilous climbers *Hedera helix* and *Dioscorea communis*. In the herbaceous layer abundant species are *Allium ursinum* and *Brachypodium sylvaticum*, accompanied by species such as *Loncomelos pyrenaicus*, *Aegopodium podagraria*, *Heracleum sphondylium*, *Lamium orvala*, *Viola reichenbachiana*.

Syntaxonomy: The floristic structure of these stands rich in *Fraxinus excelsior* and *Allium ursinum* found along the River Isonzo near Gorizia suggests their inclusion into the xero-thermophilous broad-leaved ravine *Ostryo-Tilion* alliance. This forest type is dominated by *Fraxinus excelsior* and *Tilia cordata* accompanied by *Ulmus glabra*, but is differentiated by elements related to the fluvial environment such as *Fraxinus angustifolia* subsp. *oxycarpa*, *Populus nigra*, *Salix eleagnos* and hygro-nitrophilous species such as *Parietaria officinalis*; it is characterized by a large number of thermophilous elements such as *Ruscus aculeatus* and many of the diagnostic entities of the *Ostryo-Tilion* alliance according to Košir et al. (2008). It is interpreted as a fluvial, most extreme, species-impoverished aspect of *Veratro nigri-Fraxinetum excelsioris* in its variant with *Allium ursinum* described by Dakskobler (2007) from the submediterranean-pre-Alpine region of Western Slovenia, including the Central Soča (Isonzo) Valley.

With regard to the occurrence of *Fraxinus angustifolia* subsp. *oxycarpa*, a recent study on narrow-leaved ash in North-Eastern Italy by Belletti et al. (2015) showed that in this area (specifically in the area of Farra, in which rels. 6-8 of Tab. 12 are located) many individuals have intermediate genetic and morphological characteristics between *Fraxinus angustifolia* subsp. *oxycarpa* and *F. excelsior*, which possibly originated by introgression: many individuals originally identified as narrow-leaved ash showed genetic characteristics attributable to the common ash. Hybridization could be favoured by the fact that the populations grow at the margins of the distribution area of both species and their co-presence is therefore frequent. However, these phenomena lead to strong difficulties in the identification of *Fraxinus angustifolia* subsp. *oxycarpa* in this area.

Synecology: This community is found along the torrential stretch of the River Isonzo that reaches the High Friulian Plain from Gorizia southwards, on the marginal, occasionally flooded areas of the first river terraces, on brunified fluvial soils that according to Michelutti et al. (2006) are alkaline, sandy loamy to loamy, thin to moderate deep, coarse-grained and excessively drained. Compared to *Carici albae-Fraxinetum excelsioris* it grows on soils with finer grain size. It can be considered the outermost expression of the ravine forests of the Julian pre-Alpine sector extending towards the High Plain.

Synchorology: NW Slovenia, NE Italy (Friuli Venezia Giulia) (Suppl. material 1, Fig. S1).

Annex I Habitat (92/43/EEC Directive): 91F0 (see comment to *Carici albae-Fraxinetum excelsioris*).

Conclusions

The present study provided a broader and better articulated vision of three major communities of willows and poplars that constitute typical elements of the floodplains and the first river terraces of the Po Plain river systems: the *Salicetum triandrae* willow scrub, the *Amorpho-Salicetum albae* white willow forest which is the secondary association shaped by the high occurrence of invasive species that substitutes *Salicetum albae* along the whole River Po, and the poplar-rich forest *Dioscoreo-Populetum nigrae*, which substitutes in Northern Italy the Mediterranean *Populion albae* forests and has been often named in the literature as *Salici-Populetum*.

The *Ulmus minor* and *Quercus robur*-rich forests of the Po Plain are grouped in the submediterranean alliance *Dioscoreo-Ulmion minoris,* which is enlarged to include meso-hygrophilous and mesophilous hardwood forests with oak and/or elm occurring in the lowlands along the higher terraces of rivers and their alluvial plains as well as around karstic lakes. The alliance includes forest types that substitute in the Po Plain the Central European *Fraxino-Quercion roboris* riparian forests. The study led to the description of new associations and the reclassification of two hardwood forest communities typical of the central-western Po Plain: the well-known *Polygonato-Quercetum roboris* is moved from *Alnion incanae* to *Dioscoreo-Ulmion*, while the oak-elm woods often attributed to *Querco-Ulmetum* Issler 1924 on the basis of the application of Central European schemes to the submediterranean area of Northern Italy are merged into the new association *Vinco-Ulmetum minoris*. As a result, the presence of *Querco-Ulmetum* has not yet been demonstrated unequivocally in Italy.

The study highlights the presence of *Fraxinus excelsior* forests on fluvial terraces along torrential stretches of rivers that represent the outermost expressions of the *Ostryo-Tilion* noble hardwood ravine forests going down up to the High Plain.

Finally, a peculiar *Salix alba* swamp forest, *Galio palustris-Salicetum albae* described from the Balkan Peninsula, is reported for the first time in Italy and attributed to the class *Alnetea glutinosae*, its distribution extending to Northern and Central Italy.

Waterside woodlands and scrubs of the Po Plain, althought facing severe alterations caused by human action and high alien species pressure, are still fundamental elements providing essential ecosystem services. In such an altered territory, these fragments of native vegetation, even if degraded, could be recovered and enhanced as ecological corridors or stepping stones for maintaining and promoting biodiversity and ecosystem functions at the landscape level. We addressed the remnants of waterside woody communities up to the meso-hygrophilous oak-elm woodlands, as they are valuable landmarks to delimit the areas of fluvial or lacustrine pertinence, to improve basic knowledge useful for renaturation of river ecosystems, environmental requalification in agricultural areas and actions to promote the sustainable development of agriculture.

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Syntaxonomic scheme

RHAMNO CATHARTICAE-PRUNETEA SPINOSAE Rivas Goday & Borja ex Tüxen 1962
PRUNETALIA SPINOSAE Tüxen 1952
Berberidion vulgaris Br.-Bl. 1950
Fraxino orni-Berberidenion Poldini & Vidali 1995
Salici eleagni-Juniperetum communis Poldini, Francescato, Vidali & Castello *ass. nov*.
Ulmo minoris-Paliuretum spinae-christi Poldini & Vidali *ass. nov*.

ALNETEA GLUTINOSAE Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946
ALNETALIA GLUTINOSAE Tüxen 1937
Alnion glutinosae Malcuit 1929
Galio palustris-Salicetum albae Rauš 1976

ALNO GLUTINOSAE-POPULETEA ALBAE P. Fukarek & Fabijanić 1968
POPULETALIA ALBAE Br.-Bl. ex Tchou 1948
Dioscoreo communis-Populion nigrae Poldini & Vidali in Poldini, Sburlino & Vidali 2017
Dioscoreo communis-Populetum nigrae Poldini & Vidali in Poldini, Sburlino & Vidali 2017
typicum subass. nov.
var. *Alnus incana*
populetosum albae (Biondi, Vagge, Baldoni & Taffetani 1999) Poldini, Vidali & Castello *comb. nov*.
var. *Ligustrum vulgare*
Dioscoreo-Ulmion minoris Poldini & Vidali in Poldini, Sburlino & Vidali 2017
Rhamno catharticae-Ulmetum minoris Poldini, Vidali & Castello *ass. nov*.
Lamio orvalae-Ulmetum minoris Poldini & Vidali in Poldini, Sburlino & Vidali 2017
Vinco minoris-Ulmetum minoris Poldini, Vidali & Castello *ass. nov*.
Salvio glutinosae-Quercetum roboris Poldini, Vidali & Castello *ass. nov*.
Polygonato multiflori-Quercetum roboris Sartori 1984

SALICETEA PURPUREAE Moor 1958
SALICETALIA PURPUREAE Moor 1958
Salicion albae Soó 1930
Amorpho fruticosae-Salicetum albae Poldini, Vidali, Bracco, Assini & Villani in Poldini, Vidali & Ganis 2011
populetosum nigrae Assini, Bracco, Carrea & Villani ex Poldini, Vidali & Castello *subass. nov*.
var. *Rubus caesius*
var. *Lythrum salicaria*
urticetosum dioicae Assini, Bracco, Carrea & Villani ex Poldini, Vidali & Castello *subass. nov*.
var. *Sambucus nigra* and *Cucubalus baccifer* Assini, Bracco, Carrea & Villani 2010
var. *Bidens frondosa* and *Persicaria dubia* Assini, Bracco, Carrea & Villani 2010
Salicion triandrae Müller & Görs 1958
Salicetum triandrae Malcuit 1929

QUERCO ROBORIS-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger 1937
FAGETALIA SYLVATICAE Pawłowski in Pawłowski, Sokołowski & Wallisch 1928
Ostryo carpinifoliae-Tilion platyphylli (Košir, Čarni & Di Pietro 2008) Čarni in Willner, Solomeshch, Čarni, Bergmeier, Ermakov & Mucina 2016
Carici albae-Fraxinetum excelsioris Poldini, Vidali & Castello *ass. nov*.
Veratro nigri-Fraxinetum excelsioris Dakskobler 2007

Syntaxa quoted in the text

Agrostietea stoloniferae Oberdorfer 1983; *Alnenion glutinoso-incanae* Oberdorfer 1953; *Alnion incanae* Pawłowski in Pawłowski, Sokołowski & Wallisch 1928; *Alno incanae-Pinetum sylvestris* Poldini 1984; *Alno-Fraxinetalia excelsioris* Passarge 1968; *Alno-Padion* Knapp 1942; *Alno-Ulmion* Br.-Bl. & Tüxen 1943; *Aremonio agrimonioidis-Fagion sylvaticae* (Horvat) Borhidi in Török, Podani & Borhidi 1989; *Aristolochio luteae-Quercetum pubescentis* (Horvat 1959) Poldini 2008; *Aro italici-Ulmetum minoris* Rivas-Martínez ex López 1976; *Artemisietea vulgaris* Lohmeyer, Preising & Tüxen ex Von Rochow 1951; *Asparago tenuifolii-Quercetum roboris* (Lausi 1966) Marinček 1994; *Berberidenion vulgaris* Géhu, Foucault & Delelis-Dussolier 1983; *Bidentetea tripartitae* Tüxen, Lohmeyer & Preising ex Von Rochow 1951; *Bryonio dioicae-Sambucetum nigrae* Poldini & Vidali 1995; *Caricetum elatae* Koch 1926; *Caricetum vesicariae* Chouard 1924; *Carici albae-Carpinetum betuli* Čušin 2002; *Carici albae-Tilietum cordatae* Müller & Görs 1958; *Carici elatae-Salicetum albae* Kevey 2008; *Carici remotae-Fraxinetum oxycarpae* Pedrotti 1970 corr. Pedrotti 1992; *Carici remotae-Fraxinion oxycarpae* Pedrotti ex Pedrotti, Biondi, Allegrezza & Casavecchia in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Vagge & Blasi 2014; *Carpinion betuli* Issler 1931; *Centaureo dichroanthae-Globularietum cordifoliae* Pignatti 1953; *Cladio marisci-Fraxinetum oxycarpae* Piccoli, Gerdol & Ferrari ex Piccoli 1995; *Cytision sessilifolii* Biondi in Biondi, Allegrezza & Guitian 1988; *Dauco carotae-Melilotion albi* Görs 1966; *Epilobio-Scrophularietum caninae* Koch & Br.-Bl. in Br.-Bl. 1949; *Erythronio dentis-canis-Carpinion betuli* (Horvat 1958) Marinček in Wallnöfer, Mucina & Grass 1993; *Festuco valesiacae-Brometea erecti* Br.-Bl. & Tüxen ex Br.-Bl. 1949; *Frangulo alni-Salicetum cinereae* Graebner & Hueck 1931; *Fraxino excelsioris-Acerion pseudoplatani* P.Fukarek 1969;

Fraxino-Carpinion Tüxen & Diemont 1936; *Fraxino-Quercion roboris* Passarge 1968; *Fraxino-Ulmetum* Tüxen ex Oberdorfer 1953 *typicum*; *Hippophao-Berberidetum* Moor 1958; *Junipero communis-Hippophaetum fluviatilis* Géhu & Scoppola in Géhu, Scoppola, Caniglia, Marchiori & Géhu-Franck 1984; *Lauro nobilis-Fraxinetum oxycarpae* Pedrotti & Gafta 1992; *Lauro nobilis-Fraxinion angustifoliae* I. Kárpáti & V. Kárpáti 1961; *Lauro nobilis-Ulmetum minoris* Biondi, Casavecchia, Gasparri, Pesaresi, Pirone & Di Martino in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge & Venanzoni 2015; *Lauro nobilis-Ulmion minoris* Biondi, Casavecchia, Gasparri & Pesaresi in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge & Venanzoni 2015; *Lemnetea minoris* Bolòs & Masclans 1955; *Ligustro vulgaris-Alnion glutinosae* Poldini, Sburlino & Venanzoni in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge & Venanzoni 2015; *Magnocaricion elatae* Koch 1926; *Ornithogalo pyrenaici-Carpinetum betuli* Marinček, Poldini & Zupančič ex Marinček 1994; *Periploco graecae-Ulmetum minoris* Vagge & Biondi 1999; *Phragmito australis-Magnocaricetea elatae* Klika in Klika & Novák 1941; *Polygono lapathifolii-Xanthietum italici* Pirola & Rossetti 1974; *Populion albae* Br.-Bl. ex Tchou 1948; *Potametea pectinati* Klika in Klika & Novák 1941; *Primulo vulgaris-Alnetum incanae* Sburlino, Poldini, Andreis, Giovagnoli & Tasinazzo 2012; *Pruno spinosae-Rubion ulmifolii* O. Bolòs 1954; *Pyro spinosae-Rubetalia ulmifolii* Biondi, Blasi & Casavecchia in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Vagge & Blasi 2014; *Quercetea ilicis* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952; *Querco-Ulmetum minoris* Issler 1924; *Rubo caesii-Ulmetum minoris* Brullo & Spampinato 1999; *Rubo ulmifolii-Salicetum albae* Allegrezza, Biondi & Felici 2006; *Salicetum albae* Issler 1926; *Salicetum albae* Issler 1926 *phragmito-caricetosum* Jurko 1958; *Salicetum albae* Issler 1926 *rubetosum* (Soó 1958) Šilc 2003; *Salicetum albo-triandrae* Slavnić 1952; *Salicetum incano-purpureae* Sillinger 1933; *Salicetum triandro-viminalis* Tüxen (1931) 1951; *Salici incanae-Hippophaetum* Br.-Bl. in Volk 1939; *Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantó ex Rivas-Martínez, Báscones, T.E. Díaz, Fernández-González & Loidi 2001; *Salicion pedicellatae* Galán, Pérez & Cabezudo in Pérez, Galán, P.Navas, D.Navas, Gil & Cabezudo 1999; *Salici-Populetum* Meijer Drees 1936; *Spartio juncei-Hippophaetum fluviatilis* Biondi, Vagge, Baldoni & Taffetani 1997; *Spartio juncei-Hippophaetum fluviatilis* Biondi, Vagge, Baldoni & Taffetani 1997 *typicum* Biondi, Vagge, Baldoni & Taffetani 1997; S*tellarietea mediae* Tüxen, Lohmeyer & Preising ex Von Rochow 1951; *Stipetum calamagrostis* Br.-Bl. 1918; *Symphyto bulbosi-Ulmetum minoris* Biondi & Allegrezza 1996; *Thlaspietea rotundifolii* Br.-Bl. 1948; *Tilio platyphylli-Acerion pseudoplatani* Klika 1955; *Ulmenion minoris* Oberdorfer 1953; *Ulmo-Fraxinetum angustifoliae* ass. prov. Horvat 1962; *Valeriano dioicae-Fraxinetum oxycarpae* Poldini & Sburlino 2018; *Xanthietum italici* Timar ex Mititelu & Barabaş 1972.

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Appendixes

Appendix I - Sources of relevés

Tab. 1 - Rel. 1: Osoppo (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 2: Osoppo (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 3: Peonis (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 4: S. Martino al Tagliamento (prov. PN, Friuli Venezia Giulia), C. Francescato.

Tab. 3 - Rels. 1-5: Carso (orig. Tab. 2, rels. 1, 2, 3, 4 and 5 sub Fitocenon with *Paliurus spina-christi* and *Ulmus minor* by Poldini and Vidali 1995); rels. 6-7: Lake Doberdò, southern shore (prov. GO, Friuli Venezia Giulia), 17/08/2018, M. Castello; rel. 8: Lake Doberdò, western shore (prov. GO, Friuli Venezia Giulia), 17/08/2018, M. Castello.

Tab. 4 - Rels. 1-2: Lake Doberdò (prov. GO, Friuli Venezia Giulia), 03/06/2015, L. Poldini et M. Castello; rel. 3: Lake Doberdò (prov. GO, Friuli Venezia Giulia), 24/06/2015, L. Poldini et M. Castello; rel. 4: Lake Doberdò (prov. GO, Friuli Venezia Giulia), 03/07/2017, M. Castello; rel. 5: Lake Doberdò (prov. GO, Friuli Venezia Giulia), 14/07/2017, M. Castello; rel. 6: Lake Doberdò (prov. GO, Friuli Venezia Giulia), 15/09/2015, M. Castello; rels. 7-9: Lake Idro near Lemprato (prov. BS, Lombardy) (orig. Tab. 7, rels. 1, 2 and 3 sub *Salicetum albae* Issler 1926 *phragmito-caricetosum* Jurko 1958 var. with *Carex elata* by Bolpagni et al. 2007); rels. 10-11: abandoned clay quarries of Gaggio (prov. VE, Veneto), on silty-clay soil, mineral, subject to temporary flooding, 10/06/1993, G. Sburlino; rel. 12: abandoned clay quarries of Casale (prov. VI, Veneto), on silty-clay soil, mineral, subject to temporary flooding, June 1995, G. Sburlino; rel. 13: wood of Taglio (Canale) of Mirano (prov. VE, Veneto), in a depression in the middle of the fields, on soil with greater organic component, 25/06/2008, L. Ghirelli; rel. 14: abandoned clay quarries of Luneo near Spinea-Martellago (prov. VE, Veneto), on silty-clay soil, mineral, subject to temporary flooding, 13/10/2005, L. Ghirelli; rel. 15: abandoned clay quarries of Salzano (prov. VE, Veneto), on silty-clay soil, mineral, subject to temporary flooding, 27/06/2008, L. Ghirelli; rel. 16: abandoned clay quarries of Salzano (prov. VE, Veneto), on silty-clay soil, mineral, subject to temporary flooding, 27/10/2007, L. Ghirelli; rel. 17: abandoned clay quarries of Luneo near Spinea-Martellago (prov. VE, Veneto), on silty-clay soil, mineral, subject to temporary flooding, 26/06/2008, L. Ghirelli; rel. 18: Bosco Poggioni near Padule di Fucecchio (prov. FI, Tuscany), 06/09/2006, orig. Tab. 7, rel. 6 sub Community with *Salix alba* (*Salici purpureae-Populetea nigrae*) by Lastrucci et al. 2008; rels. 19-22: Po Delta Regional Park - Punta Alberete and Valle Mandriole (prov. RA, Emilia-Romagna), 1997-1998 (orig. Tab. 1, rels. 10, 11, 12 and 13 sub Facies with *Salix alba* (*Alnetalia glutinosae*) by Merloni and Piccoli 2001).

Tab. 6 - Rel. 1: Varmo (prov. UD, Friuli Venezia Giulia), on the higher outside terracing on silty-sandy deep soils, 16/06/2004, Poldini; rel. 2: Roggia di Turrida, Sedegliano (prov. UD, Friuli Venezia Giulia), on silty-sandy more or less brunified soils, 21/07/2004, Poldini; rel. 3: river Piave, Rive of Pederobba (prov. TV, Veneto), 05/05/2000, Giovagnoli; rel. 4: Gorgo, Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 1, rel. 3 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 5: Gorgo of Latisana (prov. UD, Friuli Venezia Giulia), Francescato; rel. 6: Emilia-Romagna (orig. Tab. 1, rel. 4 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 7: Emilia-Romagna (orig. Tab. 1, rel. 9 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 8: Turrida, Spilimbergo (prov. UD, Friuli Venezia Giulia) (orig. Tab. 1, rel. 1 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 9: Murlis - Zoppola (prov. PN, Friuli Venezia

Giulia) (orig. Tab. 1, rel. 2 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 10: Emilia-Romagna (orig. Tab. 1, rel. 5 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 11: Emilia-Romagna (orig. Tab. 1, rel. 6 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 12: Emilia-Romagna (orig. Tab. 1, rel. 7 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 13: Emilia-Romagna (orig. Tab. 1, rel. 8 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 14: Osoppo (prov. UD, Friuli Venezia Giulia), Francescato; rel. 15: Loc. Macorina, San Canzian d'Isonzo (prov. GO, Friuli Venezia Giulia) (orig. Tab. 1, rel. 10 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 16: river Brenta, between Grantorto and Fontaniva (prov. PD, Veneto), Ghirelli and Sburlino (orig. Tab. 1, rel. 11 sub *Dioscoreo communis-Populetum nigrae* Poldini & Vidali in Poldini et al. 2017 by Poldini et al. 2017); rel. 17: Varmo, riverbed of Tagliamento (prov. UD, Friuli Venezia Giulia), Francescato; rel. 18: Turrida (prov. UD, Friuli Venezia Giulia), Francescato; rel. 19: Isonzo river near Fogliano (prov. GO, Friuli Venezia Giulia) (orig. Tab. 3, rel. 30 sub *Salicetum incano-purpureae* Sillinger 1933 plain form, phase with *Populus nigra* by Oriolo & Poldini 2002); rel. 20: Isonzo river near Ruda (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 31 sub *Salicetum incano-purpureae* Sillinger 1933 plain form, phase with *Populus nigra* by Oriolo & Poldini 2002); rel. 21: Osoppo (prov. UD, Friuli Venezia Giulia), Francescato; rel. 22: Gemona (prov. UD, Friuli Venezia Giulia), Francescato; rel. 23: Pioverno (prov. UD, Friuli Venezia Giulia), Francescato.

Tab. 8 - Rel. 1: Lake Doberdò (prov. GO, Friuli Venezia Giulia), 07/08/2009, Poldini; rel. 2: Doberdò, southern side (prov. GO, Friuli Venezia Giulia), 06/07/2009, Poldini; rel. 3: Doberdò (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 2B, rel. 2 by Poldini 1989); rel. 4: Doberdò (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 2B, rel. 1 by Poldini 1989); rel. 5: Doberdò (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 2B, rel. 3 by Poldini 1989); rel. 6: Doberdò (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 2A, rel. 1 by Poldini 1989); rel. 7: Doberdò (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 2A, rel. 2 by Poldini 1989); rel. 8: Doberdò (prov. GO, Friuli Venezia Giulia), 27 May 2018, M. Castello; rel. 9: Lake Doberdò, southern side (prov. GO, Friuli Venezia Giulia), 09/06/2006, Poldini; rel. 10: Doberdò (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 2B, rel. 4 by Poldini 1989); rel. 11: Mucille near Selz (prov. GO, Friuli Venezia Giulia), 05/06/2003, Poldini, Vidali & Merluzzi; rel. 12: Puglie di Domio (prov. TS, Friuli Venezia Giulia), 03/06/2006, Poldini; rel. 13: Pietrarossa (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 3, rel. 1 by Poldini 1989); rel. 14: Sablici (prov. GO, Friuli Venezia Giulia), Poldini (orig. Tab. 73, ass. 3, rel. 2 by Poldini 1989).

Tab. 9 - Rel. 1: Pumenengo (prov. BG, Lombardy) (orig. Tab. 2, rel. 1 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 2: Torre Pallavicina (prov. BG, Lombardy) (orig. Tab. 2, rel. 10 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 3: isola di Malpaga, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 12 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 4: Cascina Disperata, Barco, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 7 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 5: isola di Malpaga, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 8 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rels. 6-8: riserva di Villagana, Villachiara (prov. BS, Lombardy) (orig. Tab. 2, rels. 4, 6 and 9 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 9: bosco di Celeste, Barco, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 17 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rels. 10-11: riserva di Villagana, Villachiara (prov. BS, Lombardy) (orig. Tab. 2, rel. 5 and 11 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rels. 12-13: Cascina Corradini, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rels. 2 and 3 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 14: bosco di Celeste, Barco, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 16 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 15: Barco, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 13 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 16: presso la strada provinciale Orzinuovi - Soncino (prov. BS, Lombardy) (orig. Tab. 2, rel. 18 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 17: bosco di Celeste, Barco, Orzinuovi (prov. BS, Lombardy) (orig. Tab. 2, rel. 14 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 18: Soncino (prov. CR, Lombardy) (orig. Tab. 2, rel. 15 sub "Boschetti di olmo e farnia" by Sartori and Zucchi 1981); rel. 19: Bosco Isolone, Zelo Buon Persico (prov. MI, Lombardy) (orig. Tab. 2, rel. 13 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981); rel. 20: presso Frascarolo (prov. AL, Piedmont) (orig. Tab. 21, rel. 1 sub "Boschetti di farnia e olmo - *Polygonato multiflori-Quercetum roboris* Sartori 1980" by Bracco et al. 1984); rels. 21-22: Bassignana (prov. AL, Piedmont) (orig. Tab. 10, rels. 1 and 2 sub *Querco-Ulmetum minoris* Issler 1924 by Assini 1998); rel. 23: Cascina Rosa, bosco in Parco Zoo della Preistoria (Comune Rivolta d'Adda, prov. CR, Lombardy) (orig. Tab. 2, rel. 1 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981); rel. 24: Bosco Isolone, Zelo Buon Persico (prov. MI, Lombardy) (orig. Tab. 2, rel. 6 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981); rel. 25: Bosco Fornace, Comazzo (prov. MI, Lombardy) (orig. Tab. 2, rel. 12 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981); rel. 26: Bosco Pianelli, Comazzo (prov. MI, Lombardy) (orig. Tab. 2, rel. 2 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981); rels. 27-34: Bosco Fornace, Comazzo (prov. MI, Lombardy) (orig. Tab. 2, rels. 5, 14, 3, 4, 7, 9, 10 and 11 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981); rel. 35: Bosco Isolone, Zelo Buon Persico (prov. MI, Lombardy) (orig. Tab. 2, rel. 8 sub "Querceto misto a *Quercus robur* e *Ulmus minor*" by Cavani et al. 1981).

Tab. 10 - Rel. 1: Saline river (prov. PE, Abruzzo) (orig. Tab. 15, rel. 1 sub "Aggr. with *Salix triandra* and *Salix alba* by Pirone 1983); rel. 2: Saline river (prov. PE, Abruzzo) (orig. Tab. 13, rel. 1 sub *Salicetum triandrae* Malcuit 1929 by Pirone 1991); rel. 3: Saline river (prov. PE, Abruzzo) (orig. Tab. 15, rel. 2 sub "Aggr. with *Salix triandra* and *Salix alba* by Pirone 1983); rel. 4: Saline river (prov. PE, Abruzzo) (orig. Tab. 13, rel. 2 sub *Salicetum triandrae* Malcuit 1929 by Pirone 1991); rel. 5: Saline river (prov. PE, Abruzzo) (orig. Tab. 15, rel. 3 sub "Aggr. with *Salix triandra* and *Salix alba* by Pirone 1983); rel. 6: Saline river (prov. PE, Abruzzo) (orig. Tab. 15, rel. 5 sub "Aggr. with *Salix triandra* and *Salix alba* by Pirone 1983); rel. 7: Tagliamento river - between Casarsa and Bolzano (prov. PN and UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 716 sub *Salicetum triandrae* Malcuit 1929 by Lippert et al. 1995); rel. 8: Tagliamento river - Candussio, Ragogna (prov. UD, Friuli Venezia Giulia), 24/07/2005, L. Poldini; rel. 9: Aventino river (prov. CH, Abruzzo) (orig. Tab. 12, rel. 1 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 by Pirone et al. 2003); rel. 10: Aventino river (prov. CH, Abruzzo) (orig. Tab. 12, rel. 2 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 by Pirone et al. 2003); rel. 11: Stirone river - S. Nicomede (prov. PR, Emilia-Romagna) (orig. Tab. 14, rel. 1 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 12: Taro river - Medesano (prov. PR, Emilia-Romagna) (orig. Tab. 26, rel. 2 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 by Biondi et al. 1997); rel. 13: Stirone river - Fidenza (prov. PR, Emilia-Romagna) (orig. Tab. 14, rel. 2 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 14: Stirone river - Fidenza (prov. PR, Emilia-Romagna) (orig. Tab. 14, rel. 3 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 15: Serchio river, middle course (prov. LU, Tuscany) (orig. Tab. 10, rel. 67 sub *Salicetum triandrae* Malcuit 1929 by Arrigoni and Papini 2003); rel. 16: Serchio river, middle course (prov. LU, Tuscany) (orig. Tab. 10, rel. 14 sub *Salicetum triandrae* Malcuit 1929 by Arrigoni and Papini 2003); rel. 17: Saline river (prov. PE, Abruzzo) (orig. Tab. 15, rel. 4 sub "Aggr. with *Salix triandra* and *Salix alba* by Pirone 1983); rel. 18: Saline river (prov. PE, Abruzzo) (orig. Tab. 13, rel. 3 sub *Salicetum triandrae* Malcuit 1929 by Pirone 1991); rel. 19: Fino river, Appignani (prov. PE, Abruzzo) (orig. Tab. 2, rel. 1 sub *Salicetum triandrae* Malcuit 1929 ex Noirdalise 1955 by Pirone 2000); rel. 20: Tavo river, Congiunti (prov. PE, Abruzzo) (orig. Tab. 2, rel. 2 sub *Salicetum triandrae* Malcuit 1929 ex Noirdalise 1955 by Pirone 2000); rel. 21: Pescara river - contrada Villa Reja (prov. PE, Abruzzo) (sub "popolamenti a *Salix triandra*" by Pirone 1981); rel. 22: Brenta river - above Fontaniva (prov. PD, Veneto), 21/09/2012, G. Sburlino; rel. 23: Sangro river - Taverna Nova (prov. CH, Abruzzo) (orig. Tab. 12, rel. 3 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 by Pirone et al. 2003); rel. 24: Tagliamento river - between Mussons and Canussio (prov. PN and UD, Friuli Venezia Giulia), 09/07/2004, L. Poldini; rel. 25: Tagliamento river - Candussio, Ragogna (prov. UD, Friuli Venezia Giulia), 24/07/2005, L. Poldini; rel. 26: Taro river - Noceto, quarry lakes area (prov. PR, Emilia-Romagna) (orig. Tab. 26, rel. 3 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 by Biondi et al. 1997); rel. 27: Tagliamento river - Gorgo, embankment (prov. UD, Friuli Venezia Giulia), 04/05/2006, L. Poldini & M. Vidali; rel. 28: Tagliamento river - Gorgo, embankment (prov. UD, Friuli Venezia Giulia), 04/05/2006, L. Poldini & M. Vidali; rel. 29: Stirone river - S. Nicomede (prov. PR, Emilia-Romagna) (orig. Tab. 14, rel. 4 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 30: Tagliamento river - between Casarsa and Bolzano (prov. PN and UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 710 sub *Salicetum triandrae* Malcuit 1929 by Lippert et al. 1995); rel. 31: Tagliamento river - between Casarsa and Bolzano (prov. PN and UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 74 sub *Salicetum triandrae* Malcuit 1929 by Lippert et al. 1995); rel. 32: Tagliamento river - between Casarsa and Bolzano (prov. PN and UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 72 sub *Salicetum triandrae* Malcuit 1929 by Lippert et al. 1995); rel. 33: Taro river - Medesano (prov. PR, Emilia-Romagna) (orig. Tab. 26, rel. 1 sub *Salicetum triandrae* (Malcuit 1929) Noirfalise 1955 by Biondi et al. 1997).

Tab. 12 - Rel. 1: Sega near Zuglio (prov. UD, Friuli Venezia Giulia), Francescato; rel. 2: Villa Santina (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 3: Villa Santina (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 4: Amaro (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 5: Amaro (prov. UD, Friuli Venezia Giulia), C. Francescato; rel. 6: Farra, via della Rosta near the canal (Palude delle Fontane) on the right bank of the Isonzo river (prov. GO, Friuli Venezia Giulia), 05/06/2003, L. Poldini, M. Vidali & P. Merluzzi; rel. 7: Farra, via della Rosta along a canal on the right bank of the Isonzo river (prov. GO, Friuli Venezia Giulia), 05/06/2003, L. Poldini, M. Vidali & P. Merluzzi; rel. 8: Farra, via della Rosta, Bosco di Sotto, eastern part, on the right bank of the Isonzo river (prov. GO, Friuli Venezia Giulia), 21/05/2020, M. Castello; rel. 9: Campagnuzza near Sant'Andrea (Lucinicco), on the left bank of the Isonzo river (prov. GO, Friuli Venezia Giulia), 05/06/2003, L. Poldini, M. Vidali & P. Merluzzi.

Suppl. material 3, Tab. S2 - Rel. 1: Loc. Bolzano, Morsano al Tagliamento (prov. PN, Friuli Venezia Giulia), 15 m a.s.l., 16/04/2004, L. Poldini; rel. 2: Canussio (prov. UD, Friuli Venezia Giulia), 20 m a.s.l., 24/07/2005, L. Poldini; rel. 3: banks of the Tagliamento river near Canussio di Varmo (prov. UD, Friuli Venezia Giulia), 8 m a.s.l., 30/06/2004, L. Poldini; rel. 4: S. Mauro, third terrace of Tagliamento river (prov. UD, Friuli Venezia Giulia), 11/05/2006, C. Bravin & D. de Milleri; rel. 5: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 719 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 6: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 83 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 7: Gorgo, along the bank, facing the water of the Tagliamento river (prov. UD, Friuli Venezia Giulia), 04/05/2006, L. Poldini & M. Vidali; rel. 8: S. Mauro, fifth terrace of Tagliamento river (prov. UD, Friuli Venezia Giulia), 11/05/2006, C. Bravin & D. de Milleri; rel. 9: S. Mauro, fourth terrace of Tagliamento river (prov. UD, Friuli Venezia Giulia), 11/05/2006, C. Bravin & D. de Milleri; rel. 10: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 614 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 11: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 78 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 12: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 79 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 13: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 711 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 14: Parma creek (prov. PR, Emilia-Romagna) (orig. Tab. 7, rel. 1 sub *Salicion albae* Soó 1930 em. Moor 1958 by De Marchi et al. 1979); rel. 15: Ponte di Piave (prov. TV, Veneto), 7 m a.s.l., 12/07/1994, L. Giovagnoli, C. Lasen & P. Paiero; rel. 16: Taro river - Fornovo, railroad bridge (prov. PR, Emilia-Romagna) (orig. Tab. 27, rel. 2 sub *Salicetum albae* Issler 1926 by Biondi et al. 1997); rel. 17: Taro river - Noceto, bridge of via Emilia (prov. PR, Emilia-Romagna) (orig. Tab. 27, rel. 1 sub *Salicetum albae* Issler 1926 by Biondi et al. 1997); rel. 18: Taro river - Collecchio (prov. PR, Emilia-Romagna) (orig. Tab. 27, rel. 3 sub *Salicetum albae* Issler 1926 by Biondi et al. 1997); rel. 19: Taro river - Riccò (prov. PR, Emilia-Romagna), F. Sartori; rel. 20: Taro river - Felegara (prov. PR, Emilia-Romagna), F. Sartori; rel. 21: Taro river - Ponte Taro (prov. PR, Emilia-Romagna), F. Sartori; rel. 22: Stirone river - Fidenza, locality Il Fienile (prov. PR, Emilia-Romagna) (orig. Tab. 15, rel. 1 sub *Salicetum albae* Issler 1926 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 23: Stirone river - Fidenza (prov. PR, Emilia-Romagna) (orig. Tab. 15, rel. 2 sub *Salicetum albae* Issler 1926 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 24: Stirone river - Fidenza, locality C. Bruciata (prov. PR, Emilia-Romagna) (orig. Tab. 15, rel. 3 sub *Salicetum albae* Issler 1926 var. with *Amorpha fruticosa* by Biondi et al. 1999); rel. 25: Gorgo, Latisana (prov. UD, Friuli Venezia Giulia), scarp height 6 m from the bed of the Tagliamento river, 04/05/2006, L. Poldini, M. Vidali & C. Bravin; rel. 26: Gorgo, Latisana (prov. UD, Friuli Venezia Giulia), scarp height 6 m from the bed of the Tagliamento river, 04/05/2006, L. Poldini, M. Vidali & C. Bravin; rel. 27: Ticino river - Bereguardo (prov. PV, Lombardy) (orig. Tab. 9, rel. 17 sub *Salicetum albae* Issler 1926 by Assini, 1998); rel. 28: Tagliamento river - between Bolzano and Latisana (prov. UD, Friuli Venezia Giulia) (orig. Tab. 3, rel. 715 sub *Salicetum albae* Issler 1926 by Lippert et al. 1995); rel. 29: Middle course of the Brenta river - Piazzola e Carturo (prov. PD, Veneto), sandy-silty substrate, also with gravel, 1985, G. Sburlino; rel. 30: Middle course of the Brenta river - Carturo (prov. PD, Veneto), sandy-silty substrate, also with gravel, 1985, G. Sburlino; rel. 31: near Capraglia, plain south of the Po and Tanaro rivers (prov. AL, Piedmont), on sandy alluvial substrate (orig. Tab. 18, rel. 2 sub *Salicetum albae* Issler 1926 by Bracco et al. 1984); rel. 32: Ticino river - Besate (prov. MI, Lombardy), F. Sartori; rel. 33: Po river - Isola Serafini (prov. PC, Emilia-Romagna) (orig. Tab. 9, rel. 16 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 34: near Bassignana, plain south of the Po and Tanaro rivers (prov. AL, Piedmont), on sandy alluvial substrate (orig. Tab. 18, rel. 3 sub *Salicetum albae* Issler 1926 by Bracco et al. 1984); rel. 35: Scrivia river - Tortona (prov. AL, Piedmont), Carrea (thesis degree, unpubl.); rel. 36: near Alluvioni Cambiò, plain south of the Po and Tanaro rivers (prov. AL, Piedmont), on sandy alluvial substrate (orig. Tab. 18, rel. 1 sub *Salicetum albae* Issler 1926 by Bracco et al. 1984); rel. 37: near Bassignana, plain south of the Po and Tanaro rivers (prov. AL, Piedmont), on predominantly sandy alluvial substrate with humus reduced to a few mm of thickness (orig. Tab. 18, rel. 6 sub sub *Salicetum albae* Issler 1926 by Bracco et al. 1984); rel. 38: Po river - Bozzole (prov. AL, Piedmont) (orig. Tab. 9, rel. 3 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 39: Ticino river - Bereduardo (prov. PV, Lombardy (orig. Tab. 9, rel. 8 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 40: Ticino river - Bereduardo (prov. PV, Lombardy) (orig. Tab. 9, rel. 12 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 41: Ticino river - Bereduardo (prov. PV, Lombardy) (orig. Tab. 9, rel. 10 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 42: Ticino river - Bereduardo (prov. PV, Lombardy) (orig. Tab. 9, rel. 11 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 43: Po river - Isola Serafini (prov. PC, Emilia-Romagna) (orig. Tab. 9, rel. 1 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 44: Sesia river - Frassineto Po (prov. AL, Piedmont) (orig. Tab. 9, rel. 13 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 45: S. Maria Maddalena (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 46: Trebbia river - Puglia (prov. PC, Emilia-Romagna) (orig. Tab. 9, rel. 2 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 47: Trebbia river - Puglia (prov. PC, Emilia-Romagna) (orig. Tab. 9, rel. 14 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 48: Trebbia river - Puglia (prov. PC, Emilia-Romagna) (orig. Tab. 9, rel. 7 sub *Salicetum albae* Issler 1926 by Assini, 1998); rel. 49: Po river - Spessa Po (prov. PV, Lombardy) (orig. Tab. 9, rel. 15 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 50: Po river - Valenza (prov. AL, Piedmont) (orig. Tab. 9, rel. 9 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 51: Po river - Frascarolo (prov. AL, Piedmont) (orig. Tab. 9, rel. 4 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 52: Po river - Isola Boschina (prov. MN, Lombardy) (Sartori and Terzo 1992); rel. 53: floodplain Porto Viro downstream of the dredger (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 54: Po river - Cervesina (prov. PV, Lombardy), 2002, S. Assini; rel. 55: Golena di Panarella (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 56: Golena di Panarella (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 57: floodplain upstream of Conca Pontelagoscuro (prov. FE, Emilia-Romagna), F. Bracco & M.C. Villani; rel. 58: floodplain upstream of Occhiobello (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 59: upstream of the Porto Tolle bridge (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 60: between Contarina and Ca' Cappellino (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 61: near Ca' Venier bridge, Ca' Pisani (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 62: Polesine Camerini (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 63: Bosco Molo, Ca' Tiepolo (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 64: Ca' Venier (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 65: Ca' Pisani, Forestry Services of the Veneto Region (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 66: downstream Bottrighe bridge (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 67: Cavanella Po, near Po branch (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 68: downstream of Po di Levante deviation near the dredger (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 69: upstream of the Porto Tolle bridge (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 70: Golena Villanova Marchesana (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 71: Golena Villanova Marchesana (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 72: Papozze (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 73: upstream of Corbola (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 74: Papozze (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 75: Po river - Cervesina (prov. PV, Lombardy), 2002, S. Assini; rel. 76: Po river - Cervesina (prov. PV, Lombardy), 2002, S. Assini; rel. 77: Po river - Spessa Po (prov. PV, Lombardy) (orig. Tab. 9, rel. 5 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 78: Po river - Spessa Po (prov. PV, Lombardy) (orig. Tab. 9, rel. 6 sub *Salicetum albae* Issler 1926 by Assini 1998); rel. 79: without locality, F. Bracco & M.C. Villani; rel. 80: floodplain downstream of the pipeline (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 81: Bottrighe bridge downstream towards Mazzorno (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 82: floodplain downstream of the pipeline (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 83: Po di Goro (left bank of the river) - gorge near Rivà, Ariano nel Polesine (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 84: gorge of Salara upstream of Ficarolo (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 85: gorge of Salara upstream of Ficarolo (prov. RO, Veneto), F. Bracco & M.C. Villani; rel. 86: Lambro river - Lambrinia (prov. MI, Lombardy), Peracino (thesis degree, unpubl.); rel. 87: Ticino river - Zerbolò (prov. PV, Lombardy), F. Sartori.

Appendix II - Sporadic species

Tab. 4 - Rel. 1: *Agrostis stolonifera* L. subsp. *stolonifera* (+), *Aristolochia clematitis* L. (1), *Eleocharis palustris* (L.) Roem. & Schult. subsp. *palustris* (+), *Gratiola officinalis* L. (+), *Ranunculus repens* L. (+), *Rorippa sylvestris* (L.) Besser subsp. *sylvestris* (+), *Vitis ×ruggerii* Ardenghi, Galasso, Banfi & Lastrucci (1); rel. 2: *Rumex conglomeratus* Murray (+); rel. 3: *Vincetoxicum hirundinaria* Medik. subsp. *laxum* (Bartl.) Poldini (+); rel. 4: *Alisma lanceolatum* With. (+); rel. 5: *Allium angulosum* L. (+); rel. 6: *Allium angulosum* L. (+), *Persicaria dubia* (Stein.) Fourr. (+), *Schoenoplectus lacustris* (L.) Palla (+); rel. 7: *Euonymus europaeus* L. (1), *Galium mollugo* L. (+), *Geum urbanum* L. (+), *Humulus lupulus* L. (1), *Poa sylvicola* Guss. (1), *Valeriana officinalis* L. s.l. (r), *Vitis* sp. (1); rel. 8: *Alopecurus pratensis* L. subsp. *pratensis* (+), *Crataegus monogyna* Jacq. (1), *Euonymus europaeus* L. (+), *Fraxinus excelsior* L. subsp. *excelsior* (pl.) (1), *Galium mollugo* L. (+), *Geranium robertianum* L. (1), *Geum urbanum* L. (+), *Glechoma hederacea* L. (1), *Poa sylvicola* Guss. (+), *Prunus avium* (L.) L. (+), *Scutellaria galericulata* L. (r), *Ulmus minor* Mill. subsp. *minor* (pl.) (1), *Vitis* sp. (+); rel. 9: *Alopecurus pratensis* L. subsp. *pratensis* (r), *Crataegus monogyna* Jacq. (+), *Euonymus europaeus* L. (1), *Geranium robertianum* L. (1), *Geum urbanum* L. (1), *Glechoma hederacea* L. (+), *Inula salicina* L. (+), *Poa sylvicola* Guss. (+), *Prunus avium* (L.) L. (r), *Ranunculus acris* L. subsp. *acris* (r), *Ulmus minor* Mill. subsp. *minor* (pl.) (1), *Vitis* sp. (+); rel. 10: *Scutellaria galericulata* L. (+), *Stachys palustris* L. (+), *Symphytum officinale* L. (+); rel. 11: *Symphytum officinale* L. (+); rel. 12: *Bidens tripartita* L. s.l. (+), *Ranunculus repens* L. (+), *Viburnum opulus* L. (+); rel. 13: *Dryopteris filix-mas* (L.) Schott (+); rel. 14: *Populus nigra* L. (incl. *P. xcanadensis* Moench) (1); rel. 15: *Carex acuta* L. (+), *Carex hirta* L. (+), *Poa palustris* L. subsp. *palustris* (+), *Valeriana officinalis* L. s.l. (+); rel. 16: *Persicaria hydropiper* (L.) Delarbre (+), *Stellaria aquatica* (L.) Scop. (+), *Symphytum officinale* L. (+); rel. 17: *Populus nigra* L. (incl. *P. xcanadensis* Moench) (1); rel. 18: *Ajuga reptans* L. (1), *Lonicera caprifolium* L. (+), *Ranunculus repens* L. (r), *Rubia peregrina* L. (r), *Tussilago farfara* L. (+); rel. 19: *Bryonia dioica* Jacq. (1), *Humulus lupulus* L. (2), *Pyrus communis* L. subsp. *pyraster* (L.) Ehrh. (1), *Stachys palustris* L. (+); rel. 20: *Carex otrubae* Podp. (+); rel. 22: *Humulus lupulus* L. (1), *Stachys palustris* L. (+).

Tab. 6 - Rel. 1: *Anemonoides nemorosa* (L.) Holub (+), *Arum italicum* Mill. subsp. *italicum* (1), *Berberis vulgaris* L. (+), *Polystichum aculeatum* (L.) Roth (+), *Rubus ulmifolius* Schott (+), *Sonchus oleraceus* L. (+), *Taraxacum* F.H.Wigg. sect. *Taraxacum* (+), *Tilia cordata* Mill. (1), *Tilia platyphyllos* Scop. (1), *Viburnum lantana* L. (1); rel. 2: *Carex sylvatica* Huds. (+), *Euphorbia dulcis* L. (+), *Viola hirta* L. (2); rel. 3: *Allium ursinum* L. (+), *Aristolochia pallida* Willd. (+), *Colchicum autumnale* L. (+), *Euphorbia cyparissias* L. (+), *Lysimachia nummularia* L. (1), *Melica nutans* L. (+), *Neottia ovata* (L.) Bluff & Fingerh. (+), *Ranunculus lanuginosus* L. (+), *Thalictrum aquilegiifolium* L. subsp. *aquilegiifolium* (+); rel. 4: *Hypericum perforatum* L. subsp. *perforatum* (1), *Valeriana officinalis* L. s.l. (+); rel. 5: *Erigeron annuus* (L.) Desf. (+), *Juncus articulatus* L. subsp. *articulatus* (+), *Oenothera biennis* L. (+), *Vale-*

riana officinalis L. s.l. (+); rel. 6: *Viola odorata* L. (+); rel. 7: *Aegonychon purpurocaeruleum* (L.) Holub (+), *Arctium minus* (Hill) Bernh. (+), *Viola odorata* L. (2); rel. 8: *Angelica sylvestris* L. (1), *Berberis vulgaris* L. (+), *Chelidonium majus* L. (+), *Cirsium oleraceum* (L.) Scop. (1), *Filipendula ulmaria* (L.) Maxim. (+), *Hypericum perforatum* L. subsp. *perforatum* (2), *Knautia drymeia* Heuff. s.l. (+), *Lamium orvala* L. (+), *Limniris pseudacorus* (L.) Fuss (+), *Pimpinella major* (L.) Huds. (+), *Ruscus aculeatus* L. (+), *Viola hirta* L. (+); rel. 9: *Cirsium oleraceum* (L.) Scop. (+), *Daphne mezereum* L. (+), *Lamium orvala* L. (2), *Limniris pseudacorus* (L.) Fuss (1), *Paris quadrifolia* L. (r), *Petasites hybridus* (L.) G. Gaertn., B. Mey. et Scherb. subsp. *hybridus* (+), *Quercus robur* L. subsp. *robur* (1); rel. 10: *Acer negundo* L. (1), *Anthriscus sylvestris* (L.) Hoffm. subsp. *sylvestris* (1), *Aristolochia clematitis* L. (+), *Eupatorium cannabinum* L. subsp. *cannabinum* (+); rel. 11: *Agrimonia eupatoria* L. (+); rel. 12: *Ailanthus altissima* (Mill.) Swingle (+), *Arctium minus* (Hill) Bernh. (+), *Epipactis helleborine* (L.) Crantz (+), *Prunella vulgaris* L. (+), *Stachys sylvatica* L. (+); rel. 13: *Ailanthus altissima* (Mill.) Swingle (+), *Anthriscus sylvestris* (L.) Hoffm. subsp. *sylvestris* (+), *Eupatorium cannabinum* L. subsp. *cannabinum* (+), *Euphorbia amygdaloides* L. (+), *Prunella vulgaris* L. (+); rel. 14: *Equisetum sylvaticum* L. (+), *Galium album* Mill. subsp. *album* (+), *Lysimachia nemorum* L. (+), *Poa palustris* L. subsp. *palustris* (+); rel. 15: *Acer negundo* L. (1), *Allium ursinum* L. (1), *Bryonia dioica* Jacq. (+), *Circaea lutetiana* L. subsp. *lutetiana* (+), *Fraxinus angustifolia* Vahl subsp. *oxycarpa* (Willd.) Franco et Rocha Afonso (1), *Quercus robur* L. subsp. *robur* (1), *Reynoutria japonica* Houtt. (+), *Rumex conglomeratus* Murray (+); rel. 16: *Artemisia verlotiorum* Lamotte (+), *Chenopodium album* L. subsp. *album* (+), *Impatiens glandulifera* Royle (2), *Persicaria dubia* (Stein) Fourr. (+), *Persicaria hydropiper* (L.) Delarbre (+), *Sicyos angulatus* L. (1); rel. 17: *Equisetum telmateia* Ehrh. (+), *Potentilla indica* (Andrews) Th.Wolf (+); rel. 18: *Carex sylvatica* Huds. (+), *Euphorbia verrucosa* L. (+), *Poa pratensis* L. subsp. *pratensis* (+), *Potentilla indica* (Andrews) Th.Wolf (+); rel. 19: *Angelica sylvestris* L. (+), *Artemisia vulgaris* L. (+), *Barbarea vulgaris* R.Br. (+), *Chaenorhinum minus* (L.) Lange subsp. *minus* (r), *Chenopodium album* L. subsp. *album* (+), *Deschampsia cespitosa* (L.) P.Beauv. subsp. *cespitosa* (+), *Galium laevigatum* L. (+), *Lamium maculatum* L. (+), *Persicaria maculosa* Gray (+), *Polygonum aviculare* (aggr.) (r), *Sinapis arvensis* L. subsp. *arvensis* (+), *Solanum dulcamara* L. (+); rel. 20: *Artemisia verlotiorum* Lamotte (+), *Artemisia vulgaris* L. (+), *Daucus carota* L. s.l. (+), *Deschampsia cespitosa* (L.) P.Beauv. subsp. *cespitosa* (r), *Diplotaxis tenuifolia* (L.) DC. (+), *Erigeron annuus* (L.) Desf. (+), *Oxalis stricta* L. (+), *Ranunculus repens* L. (+), *Silene vulgaris* (Moench) Garcke subsp. *vulgaris* (+), *Solanum dulcamara* L. (+), *Solanum nigrum* L. (+); rel. 21: *Elymus repens* (L.) Gould subsp. *repens* (+), *Juniperus communis* L. (+), *Viburnum lantana* L. (2); rel. 22: *Carex flacca* Schreb. s.l. (1), *Elymus repens* (L.) Gould subsp. *repens* (+), *Fagus sylvatica* L. subsp. *sylvatica* (+), *Tommasinia altissima* (Mill.) Reduron (+); rel. 23: *Tilia cordata* Mill. (+), *Vincetoxicum hirundinaria* Medik. s.l. (+).

Tab. 8 - Rel. 1: *Agrostis stolonifera* L. subsp. *stolonifera* (1), *Allium angulosum* L. (+), *Chamaeiris graminea* (L.) Medik. (+), *Parthenocissus quinquefolia* (L.) Planch. (+), *Robinia pseudoacacia* L. (+), *Solanum dulcamara* L. (+); rel. 2: *Alkekengi officinarum* Moench (+); rel. 3: *Ophioglossum vulgatum* L. (+), *Valeriana officinalis* L. subsp. *nemorensis* (B.Turk) F.Martini & Soldano (+); rel. 5: *Acer negundo* L. (1); rel. 6: *Ophioglossum vulgatum* L. (+); rel. 7: *Lythrum salicaria* L. (2), *Salix purpurea* L. subsp. *purpurea* (+); rel. 8: *Cardamine impatiens* L. subsp. *impatiens* (1), *Carex spicata* Huds. (1); rel. 9: *Barbarea vulgaris* R.Br. (+), *Carex spicata* Huds. (2), *Fallopia dumetorum* (L.) Holub (+), *Fragaria vesca* L. subsp. *vesca* (+), *Fraxinus excelsior* L. subsp. *excelsior* (2), *Galium aparine* L. (1), *Ornithogalum divergens* Boreau (+); rel. 10: *Barbarea vulgaris* R.Br. (+), *Lamium orvala* L. (+), *Ornithogalum divergens* Boreau (+); rel. 11: *Celtis australis* L. subsp. *australis* (+), *Populus canescens* (Aiton) Sm. (1), *Quercus pubescens* Willd. subsp. *pubescens* (2), *Rubus* sect. *Corylifolii* Lindl. (+); rel. 12: *Carex pendula* Huds. (1), *Chaerophyllum temulum* L. (1), *Laurus nobilis* L. (1), *Robinia pseudoacacia* L. (1), *Rumex conglomeratus* Murray (+); rel. 13: *Eupatorium cannabinum* L. subsp. *cannabinum* (+); rel. 14: *Eupatorium cannabinum* L. subsp. *cannabinum* (+).

Tab. 9 - Rel. 1: *Equisetum palustre* L. (+); rel. 3: *Convolvulus arvensis* L. (+), *Verbena officinalis* L. (+); rel. 5: *Elymus repens* (L.) Gould subsp. *repens* (+); rel. 6: *Polygonatum odoratum* (Mill.) Druce (+); rel. 10: *Berberis vulgaris* L. (1); rel. 11: *Acer negundo* L. (1), *Galium glaucum* L. (+), *Rubus ulmifolius* Schott (1); rel. 13: *Bidens tripartita* L. s.l. (+), *Circaea lutetiana* L. subsp. *lutetiana* (1), *Geum urbanum* L. (+), *Vincetoxicum hirundinaria* Medik. s.l. (+); rel. 14: *Carex sylvatica* Huds. (+), *Euphorbia dulcis* L. (1), *Ornithogalum divergens* Boreau (+); rel. 15: *Knautia drymeia* Heuff. s.l. (2); rel. 17: *Hemerocallis fulva* (L.) L. (1), *Humulus lupulus* L. (1), *Luzula pilosa* (L.) Willd. (1), *Neottia ovata* (L.) Bluff & Fingerh. (1), *Taraxacum* F.H.Wigg. sect. *Taraxacum* (+), *Thalictrum aquilegiifolium* L. subsp. *aquilegiifolium* (1); rel. 18: *Alliaria petiolata* (M.Bieb.) Cavara & Grande (+), *Anemonoides ranunculoides* (L.) Holub (+), *Artemisia vulgaris* L. (1), *Brassica rapa* L. s.l. (+), *Cardamine hirsuta* L. (+), *Cerastium glomeratum* Thuill. (+), *Convolvulus arvensis* L. (1), *Daucus carota* L. s.l. (+), *Microthlaspi perfoliatum* (L.) F.K.Mey. (+), *Poa trivialis* L. (1), *Rhamnus saxatilis* Jacq. (2), *Solanum nigrum* L. (+), *Stellaria media* (L.) Vill. subsp. *media* (1), *Torilis arvensis* (Huds.) Link s.l. (+), *Veronica persica* Poir. (1); rel. 20: *Cornus mas* L. (1), *Galeopsis tetrahit* L. (+); rel. 21: *Convolvulus sepium* L. (+), *Crataegus laevigata* (Poir.) DC. (1), *Oxalis stricta* L. (+), *Populus alba* L. (+), *Viola alba* Besser s.l. (+); rel. 22: *Aristolochia clematitis* L. (1), *Convolvulus sepium* L. (+), *Crataegus laevigata* (Poir.) DC. (+), *Humulus lupulus* L. (+), *Persicaria minor* (Huds.) Opiz (+), *Populus alba* L. (1); rel. 35: *Daphne mezereum* L. (1).

Tab. 10 - Rel. 1: *Bolboschoenus maritimus* (L.) Palla (1), *Lolium temulentum* L. (+); rel. 2: *Cardamine pratensis* L. (1); rel. 3: *Lotus tenuis* Waldst. & Kit. ex Willd. (+); rel. 4: *Lotus tenuis* Waldst. & Kit. ex Willd. (+); rel. 5: *Bolboschoenus maritimus* (L.) Palla (+), *Sonchus oleraceus* L. (r), *Typha minima* Funk ex Hoppe (+); rel. 6: *Typha angustifolia* L. (+); rel. 8: *Epilobium hirsutum* L. (+), *Platanus hispanica* Mill. ex Münchh. (1), *Solidago gigantea* Aiton (+); rel. 10: *Epilobium hirsutum* L. (1), *Potentilla reptans* L. (1); rel. 12: *Cornus sanguinea* L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó) (+); rel. 13: *Galium mollugo* L. (+); rel. 14: *Crataegus monogyna* Jacq. (+), *Elymus repens* (L.) Gould subsp. *repens* (2); rel. 15: *Parietaria officinalis* L. (1), *Sambucus ebulus* L. (+); rel. 16: *Alnus incana* (L.) Moench (1), *Barbarea vulgaris* R.Br. (+), *Cardamine pratensis* L. (r), *Galatella pannonica* (Jacq.) Galasso, Bartolucci & Ardenghi (r), *Galeopsis tetrahit* L. (r), *Helosciadium nodiflorum* (L.) W.D.J.Koch subsp. *nodiflorum* (2), *Humulus lupulus* L. (r), *Lapsana communis* L. subsp. *communis* (r), *Oenanthe pimpinelloides* L. (+), *Rorippa sylvestris* (L.) Besser subsp. *sylvestris* (1), *Saponaria officinalis* L. (r), *Silene latifolia* Poir. (r), *Stellaria media* (L.) Vill. subsp. *media* (r), *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica* (+), *Viola alba* Besser s.l. (r); rel. 17: *Arundo plinii* Turra (+), *Cynodon dactylon* (L.) Pers. (+), *Medicago lupulina* L. (r), *Pastinaca sativa* L. (incl. subsp. *urens* (Req. ex Godr.) Čelak.) (+), *Scirpoides holoschoenus* (L.) Soják (+), *Sulla coronaria* (L.) Medik. (r), *Typha angustifolia* L. (+), *Verbena officinalis* L. (+); rel. 18: *Pastinaca sativa* L. (incl. subsp. *urens* (Req. ex Godr.) Čelak.) (+), *Scirpoides holoschoenus* (L.) Soják (+); rel. 20: *Trigonella alba* (Medik.) Coulot & Rabaute (+); rel. 21: *Angelica sylvestris* L. subsp. *sylvestris* (+), *Carex pendula* Huds. (+), *Cirsium vulgare* (Savi) Ten. s.l. (+), *Equisetum telmateia* Ehrh. (+), *Galium mollugo* L. (+), *Helosciadium nodiflorum* (L.) W.D.J.Koch subsp. *nodiflorum* (r), *Mentha aquatica* L. subsp. *aquatica* (+), *Raphanus raphanistrum* L. s.l. (r), *Rumex crispus* L. (+), *Symphytum tuberosum* L. subsp. *angustifolium* (A.Kern.) Nyman (+), *Thalictrum flavum* L. (+); rel. 22: *Chenopodium album* L. subsp. *album* (+), *Impatiens glandulifera* Royle (1), *Persicaria dubia* (Stein.) Fourr. (2), *Rorippa sylvestris* (L.) Besser subsp. *sylvestris* (+); rel. 23: *Alnus glutinosa* (L.) Gaertn. (1), *Equisetum palustre* L. (1), *Ficaria verna* Huds. s.l. (+), *Hypericum tetrapterum* Fr. (+), *Trifolium pratense* L. s.l. (+); rel. 24: *Chaenorhinum minus* (L.) Lange subsp. *minus* (+), *Cynodon dactylon* (L.) Pers. (+), *Diplotaxis tenuifolia* (L.) DC. (+), *Galinsoga quadriradiata* Ruiz & Pav. (+), *Juncus bufonius* L. (+), *Persicaria pensylvanica* (L.) M.Gómez (+), *Scrophularia canina* L. (+), *Solidago gigantea* Aiton (+); rel. 25: *Echium vulgare* L. subsp. *vulgare* (+), *Equisetum variegatum* Schleich. ex F.Weber & D.Mohr (+), *Galeopsis angustifolia* Ehrh. ex Hoffm. subsp. *angustifolia* (+), *Oenothera biennis* L. (+), *Oxalis stricta* L. (+), *Scrophularia canina* L. (+); rel. 27: *Acer campestre* L. (r), *Juncus inflexus* L. subsp. *inflexus* (+), *Lysimachia vulgaris* L. (+), *Veronica beccabunga* L. (1); rel. 28: *Acer campestre* L. (r), *Juncus inflexus* L. subsp. *inflexus* (+), *Lysimachia vulgaris* L. (+), *Veronica beccabunga* L. (+); rel. 30: *Diplotaxis tenuifolia* (L.) DC. (+), *Plantago lanceolata* L. (1), *Reseda lutea* L. subsp. *lutea* (+), *Setaria italica* (L.) P.Beauv. subsp. *viridis* (L.) Thell. (+), *Silene vulgaris* (Moench) Garcke subsp. *vulgaris* (r); rel. 31: *Chaenorhinum minus* (L.) Lange subsp. *minus* (r), *Juncus bufonius* L. (+), *Oenothera biennis* L. (r), *Plantago lanceolata* L. (+), *Polygonum aviculare* (aggr.) (+), *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica* (+); rel. 32: *Bidens cernua* L. (+); rel. 33: *Clematis vitalba* L. (1), *Robinia pseudoacacia* L. (1).

Tab. 12 - Rel. 1: *Abies alba* Mill. (1), *Aquilegia vulgaris* L. (+), Carex digitata L. (1), *Carpinus betulus* L. (1), *Castanea sativa* Mill. (+), *Cyclamen purpurascens* Mill. subsp. *purpurascens* (+), *Galium laevigatum* L. (+), *Lilium martagon* L. (+), *Luzula nivea* (Nathh.) DC. (+), *Platanthera bifolia* (L.) Rich. (+), *Sesleria caerulea* (L.) Ard. subsp. *caerulea* (1), *Solidago virgaurea* L. subsp. *virgaurea* (+), *Sorbus aria* (aggr.) (+); rel. 2: *Anemonoides nemorosa* (L.) Holub (1), *Angelica sylvestris* L. subsp. *sylvestris* (+), *Anthoxanthum australe* (Weber) Veldkamp (+), *Aposeris foetida* (L.) Less. (+), *Frangula alnus* Mill. subsp. *alnus* (+), *Juniperus communis* L. (+), *Mycelis muralis* (L.) Dumort. subsp. *muralis* (+), *Polygonatum odoratum* (Mill.) Druce (1), *Ranunculus tuberosus* Lapeyr. (+), *Salix caprea* L. (+), *Symphytum tuberosum* L. subsp. *angustifolium* (A.Kern.) Nyman (+); rel. 3: *Aquilegia atrata* W.D.J.Koch (+), *Asarum europaeum* L. subsp. *caucasicum* (Duch.) Soó (1), *Asparagus tenuifolius* Lam. (+), *Campanula trachelium* L. subsp. *trachelium* (+), *Carex sylvatica* Huds. (+), *Chaerophyllum hirsutum* L. (+), *Dryopteris filix-mas* (L.) Schott (+), *Epimedium alpinum* L. (+), *Filipendula ulmaria* (L.) Maxim. (+), *Lamium galeobdolon* (L.) L. subsp. *flavidum* (F.Herm.) A.Löve & D.Löve (1), *Lysimachia vulgaris* L. (+), *Pulmonaria officinalis* L. subsp. *officinalis* (+), *Rosa arvensis* Huds. (+), *Taxus baccata* L. (+); rel. 4: *Alnus incana* (L.) Moench (+), *Equisetum hyemale* L. (+), *Pinus nigra* J.F.Arnold subsp. *nigra* (1), *Viola hirta* L. (+); rel. 5: *Quercus robur* L. subsp. *robur* (+), *Vincetoxicum hirundinaria* Medik. s.l. (+); rel. 6: *Dactylis glomerata* L. subsp. *glomerata* (+), *Populus alba* L. (incl. *P. canescens* (Aiton) Sm.) (1); rel. 7: *Arum italicum* Mill. subsp. *italicum* (+), *Carex pendula* Huds. (+); rel. 8: *Helleborus odorus* Waldst. & Kit. subsp. *laxus* (Host) Merxm. & Podlech (+); rel. 9: *Lonicera japonica* Thunb. (1), *Platanus hispanica* Mill. ex Münchh. (1).

Suppl. material 3, Tab. S2 - Rel. 1: *Tussilago farfara* L. (1), *Veronica beccabunga* L. (+), *Vitis vinifera* L. (incl. *V. riparia* Michx.) (+); rel. 2: *Ligustrum vulgare* L. (1), *Vitis vinifera* L. (incl. *V. riparia* Michx.) (+); rel. 3: *Equisetum fluviatile* L. (+), *Tommasinia altissima* (Mill.) Reduron (+); rel. 4: *Buddleja davidii* Franch. (+); rel. 5: *Bidens tripartita* L. s.l. (+), *Deschampsia cespitosa* (L.) P.Beauv. subsp. *cespitosa* (1); rel. 6: *Tanacetum vulgare* L. subsp. *vulgare* (1); rel. 7: *Equisetum hyemale* L. (+), *Lolium arundinaceum* (Schreb.) Darbysh. subsp. *arundinaceum* (+); rel. 8: *Acer campestre* L. (+), *Buddleja davidii* Franch. (2), *Lonicera caprifolium* L. (1), *Platanus hispanica* Mill. ex Münchh. (+); rel. 9: *Angelica sylvestris* L. subsp. *sylvestris* (1), *Galium mollugo* L. (+), *Myosotis scorpioides* L. subsp. *scorpioides*

(+), *Persicaria minor* (Huds.) Opiz (1), *Platanus hispanica* Mill. ex Münchh. (+); rel. 10: *Centaurium pulchellum* (Sw.) Druce subsp. *pulchellum* (r), *Cuscuta campestris* Yunck. (1), *Deschampsia cespitosa* (L.) P.Beauv. subsp. *cespitosa* (1), *Diplotaxis tenuifolia* (L.) DC. (+), *Echium vulgare* L. subsp. *vulgare* (+), *Elymus acutus* (DC.) M.A.Thiébaud (1), *Galeopsis angustifolia* Ehrh. ex Hoffm. subsp. *angustifolia* (+), *Medicago lupulina* L. (+), *Panicum capillare* L. (1), *Setaria italica* (L.) P.Beauv. subsp. *viridis* (L.) Thell. (1), *Trifolium repens* L. (+), *Trigonella alba* (Medik.) Coulot & Rabaute (+), *Tussilago farfara* L. (+); rel. 11: *Centaurea jacea* L. (+), *Pulicaria dysenterica* (L.) Bernh. (+), *Sorghum halepense* (L.) Pers. (+), *Symphyotrichum novi-belgii* (L.) G.L.Nesom (+); rel. 12: *Centaurea jacea* L. (r), *Equisetum fluviatile* L. (+), *Poa compressa* L. (+), *Tanacetum vulgare* L. subsp. *vulgare* (1); rel. 13: *Equisetum palustre* L. (+), *Equisetum variegatum* Schleich. ex F.Weber & D. Mohr (+), *Euphorbia falcata* L. subsp. *falcata* (r), *Scabiosa triandra* L. (r), *Scrophularia canina* L. (+), *Setaria italica* (L.) P.Beauv. subsp. *viridis* (L.) Thell. (r), *Taraxacum* F.H.Wigg. sect. *Taraxacum* (r); rel. 14: *Amaranthus retroflexus* L. (+), *Brassica nigra* (L.) W.D.J.Koch (+), *Convolvulus arvensis* L. (+), *Persicaria minor* (Huds.) Opiz (1), *Populus alba* L. (+); rel. 15: *Arctium lappa* L. (+), *Blackstonia perfoliata* (L.) Huds. s.l. (+), *Centaurium erythraea* Rafn subsp. *erythraea* (+), *Cuscuta cesattiana* Bertol. (+), *Diplotaxis tenuifolia* (L.) DC. (+), *Elymus caninus* (L.) L. (+), *Galeopsis angustifolia* Ehrh. ex Hoffm. subsp. *angustifolia* (1), *Juncus articulatus* L. subsp. *articulatus* (+), *Matricaria discoidea* DC. (+), *Reseda lutea* L. subsp. *lutea* (+), *Rorippa palustris* (L.) Besser (+), *Vicia cracca* L. (+); rel. 16: *Cirsium arvense* (L.) Scop. (+), *Petasites hybridus* (L.) G. Gaertn., B.Mey. & Scherb. subsp. *hybridus* (+); rel. 17: *Bolboschoenus maritimus* (L.) Palla (2), *Cuscuta cesattiana* Bertol. (+), *Schoenoplectus tabernaemontani* (C.C.Gmel.) Palla (+); rel. 18: *Tussilago farfara* L. (+); rel. 19: *Trigonella alba* (Medik.) Coulot & Rabaute (1); rel. 20: *Alisma plantago-aquatica* L. (+), *Dittrichia viscosa* (L.) Greuter subsp. *viscosa* (+), *Juncus articulatus* L. subsp. *articulatus* (+), *Trigonella alba* (Medik.) Coulot & Rabaute (+), *Verbena officinalis* L. (+); rel. 21: *Dittrichia viscosa* (L.) Greuter subsp. *viscosa* (+), *Trigonella alba* (Medik.) Coulot & Rabaute (+); rel. 24: *Arundo donax* L. (+), *Prunus avium* (L.) L. (+); rel. 25: *Crataegus monogyna* Jacq. (1), *Crepis vesicaria* L. subsp. *taraxacifolia* (Thuill.) Thell. (+), *Galium mollugo* L. (+), *Hedera helix* L. subsp. *helix* (+), *Holcus lanatus* L. subsp. *lanatus* (1), *Hypericum perforatum* L. subsp. *perforatum* (+), *Lonicera caprifolium* L. (+), *Lotus maritimus* L. (+), *Prunus avium* (L.) L. (+), *Quercus robur* L. subsp. *robur* (+), *Taraxacum* F.H.Wigg. sect. *Taraxacum* (+); rel. 26: *Crataegus monogyna* Jacq. (+), *Potentilla indica* (Andrews) Th.Wolf (+), *Prunus avium* (L.) L. (+); rel. 27: *Galeopsis pubescens* Besser (+), *Holcus lanatus* L. subsp. *lanatus* (+), *Lolium giganteum* (L.) Darbysh. (1), *Prunus padus* L. s.l. (3), *Reynoutria japonica* Houtt. (+), *Rubus* gr. *Suberecti* P.J. Müll. (1); rel. 28: *Deschampsia cespitosa* (L.) P.Beauv. subsp. *cespitosa* (+), *Equisetum hyemale* L. (+); rel. 29: *Aegopodium podagraria* L. (1), *Carex hirta* L. (+), *Elymus caninus* (L.) L. (+), *Equisetum telmateia* Ehrh. (+), *Mentha longifolia* (L.) L. (+), *Rumex sanguineus* L. (+), *Solanum dulcamara* L. (+); rel. 30: *Carex pendula* Huds. (2), *Elymus caninus* (L.) L. (1), *Equisetum telmateia* Ehrh. (1), *Populus alba* L. (+); rel. 31: *Bidens tripartita* L. s.l. (+), *Lolium perenne* L. (+); rel. 32: *Galeopsis tetrahit* L. (+); rel. 33: *Anisantha sterilis* (L.) Nevski (1), *Aristolochia clematitis* L. (5), *Ulmus minor* Mill. subsp. *minor* (3); rel. 34: *Brachypodium rupestre* (Host) Roem. & Schult. (incl. subsp. *cespitosum* (Host) Scholz) (+), *Carex pendula* Huds. (+), *Staphylea pinnata* L. (+); rel. 35: *Angelica sylvestris* L. subsp. *sylvestris* (+), *Ballota nigra* L. s.l. (+), *Berberis vulgaris* L. (+), *Chaerophyllum temulum* L. (+), *Glechoma hederacea* L. (1), *Heracleum sphondylium* L. s.l. (+), *Mentha arvensis* L. (+), *Populus alba* L. (+), *Raphanus raphanistrum* L. s.l. (+); rel. 36: *Bidens tripartita* L. s.l. (+), *Brachypodium rupestre* (Host) Roem. & Schult. (incl. subsp. *cespitosum* (Host) Scholz) (+), *Fallopia convolvulus* (L.) Á.Löve (+), *Galeopsis pubescens* Besser (+), *Leersia oryzoides* (L.) Sw. (+), *Solanum dulcamara* L. (1), *Stellaria aquatica* (L.) Scop. (+), *Symphytum officinale* L. (+); rel. 37: *Galeopsis tetrahit* L. (+), *Rumex obtusifolius* L. s.l. (+), *Scrophularia nodosa* L. (+), *Solanum dulcamara* L. (+), *Symphytum officinale* L. (+); rel. 38: *Bidens tripartita* L. s.l. (+), *Carex riparia* Curtis (2); rel. 40: *Calamagrostis canescens* (Weber) Roth subsp. *canescens* (4); rel. 41: *Carex elata* All. subsp. *elata* (+), *Viburnum opulus* L. (1); rel. 42: *Tanacetum vulgare* L. subsp. *vulgare* (+), *Viburnum opulus* L. (+); rel. 43: *Anisantha sterilis* (L.) Nevski (+), *Fallopia convolvulus* (L.) Á.Löve (+); rel. 45: *Stellaria aquatica* (L.) Scop. (1); rel. 46: *Carex hirta* L. (+), *Cuscuta campestris* Yunck. (2), *Lolium multiflorum* Lam. (2), *Phytolacca americana* L. (+), *Sonchus oleraceus* L. (+); rel. 47: *Lolium perenne* L. (1), *Persicaria minor* (Huds.) Opiz (+); rel. 48: *Lysimachia nummularia* L. (+), *Oxalis stricta* L. (+); rel. 49: *Lysimachia nummularia* L. (+), *Raphanus raphanistrum* L. s.l. (+), *Taraxacum* F.H.Wigg. sect. *Taraxacum* (+); rel. 50: *Juglans regia* L. (2), *Lepidium virginicum* L. (+), *Lolium multiflorum* Lam. (+), *Oxalis stricta* L. (+), *Sorghum halepense* (L.) Pers. (+); rel. 51: *Carex elata* All. subsp. *elata* (3); rel. 52: *Galeopsis tetrahit* L. (+); rel. 53: *Potentilla reptans* L. (2); rel. 54: *Rapistrum rugosum* (L.) All. (+); rel. 55: *Berberis vulgaris* L. (+), *Scutellaria galericulata* L. (+); rel. 56: *Quercus robur* L. subsp. *robur* (+); rel. 57: *Aristolochia clematitis* L. (+), *Ulmus minor* Mill. subsp. *minor* (+); rel. 64: *Sambucus ebulus* L. (+); rel. 66: *Ranunculus circinatus* Sibth. (+); rel. 69: *Symphytum officinale* L. (+); rel. 70: *Diplotaxis tenuifolia* (L.) DC. (+), *Galinsoga quadriradiata* Ruiz & Pav. (+), *Lepidium virginicum* L. (+), *Phytolacca americana* L. (+); rel. 71: *Galeopsis speciosa* Mill. (+), *Symphyotrichum squamatum* (Spreng.) G.L.Nesom (+); rel. 72: *Gratiola officinalis* L. (+), *Sonchus arvensis* L. s.l. (+), *Symphyotrichum squamatum* (Spreng.) G.L.Nesom (+); rel. 73: *Gratiola officinalis* L. (+); rel. 74: *Solanum dulcamara* L. (+); rel. 75: *Amaranthus hybridus* L. subsp. *cruentus* (L.) Thell. (+), *Cyperus longus* L. (+), *Cyperus strigosus* L. (+), *Lepidium virginicum* L. (+), *Panicum dichotomiflorum* Michx. (+), *Raphanus raphanistrum* L. s.l. (+), *Reynoutria* *japonica* Houtt. (+), *Stellaria aquatica* (L.) Scop. (1), *Ulmus minor* Mill. subsp. *minor* (+); rel. 76: *Amaranthus hybridus* L. subsp. *cruentus* (L.) Thell. (+), *Ballota nigra* L. s.l. (+), *Cyperus fuscus* L. (+), *Digitaria sanguinalis* (L.) Scop. (+), *Galinsoga quadriradiata* Ruiz & Pav. (+), *Panicum dichotomiflorum* Michx. (+); rel. 77: *Leersia oryzoides* (L.) Sw. (1); rel. 79: *Arabidopsis thaliana* (L.) Heynh. (+), *Papaver rhoeas* L. subsp. *rhoeas* (+), *Tanacetum corymbosum* (L.) Sch.Bip. s.l. (+), *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica* (+); rel. 80: *Arabidopsis thaliana* (L.) Heynh. (+), *Symphyotrichum squamatum* (Spreng.) G.L.Nesom (+), *Veronica beccabunga* L. (+); rel. 81: *Arabidopsis thaliana* (L.) Heynh. (1), *Convolvulus arvensis* L. (+), *Hypericum tetrapterum* Fr. (+), *Tanacetum corymbosum* (L.) Sch.Bip. s.l. (+), *Veronica beccabunga* L. (1); rel. 83: *Anisantha sterilis* (L.) Nevski (+), *Carex remota* L. (+), *Glechoma hederacea* L. (1), *Holcus lanatus* L. subsp. *lanatus* (+), *Juglans regia* L. (+), *Lolium arundinaceum* (Schreb.) Darbysh. subsp. *arundinaceum* (+), *Potentilla reptans* L. (+); rel. 84: *Eragrostis pilosa* (L.) P.Beauv. subsp. *pilosa* (1), *Panicum capillare* L. (+), *Polygonum aviculare* L. subsp. *aviculare* (+); rel. 87: *Aristolochia clematitis* L. (+), *Berberis vulgaris* L. (+), *Hypericum tetrapterum* Fr. (+), *Rumex acetosa* L. subsp. *acetosa* (+).

Supplementary material 1

Figure S1

Authors: Livio Poldini, Marisa Vidali, Miris Castello, Giovanni Sburlino

Data type: occurences

Explanation note: Distribution map of hygrophilous and meso-hygrophilous woody communities described in this paper (*Salici eleagni-Juniperetum communis*, *Ulmo minoris-Paliuretum spinae-christi*, *Rhamno catharticae-Ulmetum minoris*, *Vinco minoris-Ulmetum minoris*, *Salvio glutinosae-Quercetum roboris*, *Carici albae-Fraxinetum excelsioris*), *Galio palustris-Salicetum albae* and *Veratro nigri-Fraxinetum excelsioris* in Italy. Map created with QGIS; basic data from Geoportale Nazionale (http://www.pcn.minambiente.it/mattm/).

Link: https://doi.org/10.3897/PlantSociology.57.52760.suppl1

Supplementary material 2

Table S1

Authors: Livio Poldini, Marisa Vidali, Miris Castello, Giovanni Sburlino

Data type: synoptic table

Explanation note: Simplified synoptic table of the associations included in *Dioscoreo-Ulmion*. Species with frequency < 30 % are not reported in the table, except those with phytosociological significance. Differential species of associations are reported in bold. 1: *Rhamno catharticae-Ulmetum minoris ass. nov.* (Tab. 8 in this paper); 2: *Lamio orvalae-Ulmetum minoris* (Poldini et al. 2017); 3: *Polygonato multiflori-Quercetum roboris* (Sartori 1984; Assini 2011a); 4: *Vinco minoris-Ulmetum minoris ass. nov.* (Tab. 9 in this paper); 5: *Salvio glutinosae-Quercetum roboris ass. nov.* (orig. Tab. 1 rels. 1-7 sub “Boschi igrofili a *Populus alba*” by Cavani et al. 1981). Cl: species of *Alno glutinosae-Populetea albae*; All: species of *Dioscoreo-Ulmion minoris*; d ass: differential species of association.

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Supplementary material 3

Table S2

Authors: Livio Poldini, Marisa Vidali, Miris Castello, Giovanni Sburlino

Data type: phytosociological table

Explanation note: *Amorpho fruticosae–Salicetum albae*, *populetosum nigrae subass. nov.* (rels. 1-24), *urticetosum dioicae subass. nov.* (rels. 25-87). Relevés are arranged according to cluster analysis (cover data, Similarity ratio, UPGMA). Cl: species of *Salicetea purpureae*; All: species of *Salicion albae*; A: alien species.

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The vegetation of a historic road system in the suburban area of Monte Pellegrino (Palermo, Sicily)

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Abstract

Knowledge of the processes by which plants colonize old structures is a key element for nature-based design both in urban and suburban contexts. This paper analyses the natural vegetation on walls and in other microhabitats of the roadway structures of Monte Pellegrino (606 m a.s.l.) near Palermo (Sicily), built in the first half of the 1900s. The historical road has particular construction and architectural features, and its characteristics have been maintained to this day. The route, approximately 16 kilometers long, is well integrated within a site of high naturalistic value which has been designated as a Special Area of Conservation (ITA020014) of the Natura 2000 network, and it is also a regional natural reserve. The survey was carried out on different homogeneous ecological contexts based on different microhabitats (masonry retaining walls, masonry guardwalls, road margins, and rock cut slopes) which are diversified according to other environmental factors (building materials, inclination, height, and exposure). The phytosociological and statistical analysis has led to the description of six new associations (*Crepido bursifoliae-Parietarietum judaicae* ass. nov., *Athamanto siculae-Parietarietum judaicae* ass. nov., *Helichryso panormitani-Hypochaeridetum laevigatae* ass. nov., *Diantho siculi-Helichrysetum panormitani* Gianguzzi ass. nov., *Olopto miliacei-Pennisetetum setacei* Gianguzzi ass. nov., *Teucrio flavi-Rhoetum coriariae* Gianguzzi ass. nov.) and one sub-association (*Rhamno alaterni-Euphorbietum dendroidis* Géhu & Biondi 1997 *artemisietosum arborescentis* subass. nov.). Other chasmophytic formations (*Centranthetum rubri* Oberd. 1969, *Antirrhinetum siculi* Bartolo & Brullo 1986) were reported for the first time in this area.

Keywords

Asplenietea trichomanis, chasmophytic vegetation, colonization, man-made habitat, wall vegetation, syntaxonomy

Introduction

Road systems have accompanied humans since their earliest civilizations, profoundly affecting ecosystems and landscape characteristics in many parts of the world. In addition, they also provide new anthropogenic habitats for flora and plant communities, as well as for fauna (Hobbs et al. 2006; Lososová et al. 2010; Bontoux et al. 2019). This is particularly relevant in suburban and rural areas where road systems are the primary artificial elements that shape their landscapes (Forman 2002).

Although road systems may differ according to their age, construction methods, and types of building materials, all these different systems form specific ecosystems due to the great variety of habitats they provide (walls, masonry parapets, road margins, cut slopes). Plants colonize these different habitats, driven by ecological gradients that define specific "microgeoseries" (*sensu* Rivas-Martínez 2002) for each environmental context.

Before the use of concrete as a building material, road routes made use of mortared masonry walls or dry-laid walls as retaining structures. These were built by specialized craftsmen who selected and shaped the rocks at the work site, and surfaces were paved with cobblestones instead of asphalt. In Italy, as well as in various other areas of the Mediterranean, these types of road layouts are widespread today, although most of them have been modified by adding asphalt on top of the cobblestone layer. These kinds of roadways persist mainly in mountainous areas or in places with steep and rugged terrain where they resist exposure to severe weather conditions as well as the normal wear and tear that occurs over time. Overall, the architectural beauty of these works stands out, as does, in particular, the building effectiveness of the stone masonry walls which bridge differences in height by creating steep hairpin bends on mountainsides. These structures characterize mountain landscapes like that of the Stelvio Pass's hairpin bends (Pedrana 2011), but they also feature in the tight curves of Monte Pellegrino, near Palermo (the study area of this paper), their presence a testimony to the endurance of human workmanship.

The old structures of road systems offer considerable new spaces for plant colonization and are covered by plant communities which are micromorphologically diversified in relation to their floristic and physiognomic aspects (inclination, exposition, height of surfaces).

A number of botanical and ecological studies of suburban road systems have focused on the role of road margins primarily as corridors for the diffusion of allochthonous species that use these communication routes as expansion corridors (Kowarick 2003; Kalwij et al. 2008; McDougall et al. 2018; Pasta et al. 2010). On the contrary, other authors have considered road margins as refuge habitat for native plants in highly disturbed landscapes such as urban areas or near industrial or intensive agricultural systems (Forman and Alexander 1998; Rentch et al. 2005; Arenas et al. 2017; Lázaro-Lobo and Ervin 2019). With regard to the walls involved in these roadways, *sensu lato*, research on vegetation has especially highlighted the role of plants as biodeteriogens of artifacts of cultural interest (Caneva et al. 1992, 1995; Caneva and Ceschin 2009; Ceschin et al. 2006, 2016; Li et al. 2016). Plant communities growing on ancient walls have been analyzed both from an ecological-conservation point of view – as a refuge habitat for specialized flora (Segal, 1969; Meral et al. 2018; Huang et al. 2019) – as well as in phytosociological terms, through the characterization of specific syntaxa (Hruška 1987; Brullo and Guarino 1998, 2002; Gamper and Bacchetta 2001). Road cut slopes have also been the subject of specific studies that have analyzed colonization processes and similarities with natural rock communities (Bochet et al. 2009).

The aim of this work is the phytosociological investigation of vegetation on walls and in other microhabitats of the road system of Monte Pellegrino (the mountain towering above the city of Palermo) and the interpretation of species composition patterns of plant communities along the roadway structures. The road system can be considered "historical"; in fact, it was inaugurated in 1924. Its route, approximately 16 kilometers long, climbs along the slopes of the mountain with hairpin bends and short straightaways, and it is well integrated within an area of particular naturalistic value which has been designated as a Special Area of Conservation (ITA020014) of the Natura 2000 network and is a regional natural reserve.

The study also addresses the issue of bio-ecological and phytocoenotic stability established in the road system that has been triggered by the slow colonization process within the different microhabitats (masonry retaining walls, masonry guardwalls, road margins, and rock cut slopes) and which are diversified according to other environmental factors (building materials, inclination, height, and exposure).

There are not many other studies in the Mediterranean area about plants growing on all components of a road system. Therefore, the data collected are suitable for two practical applications: (I) knowledge of so-called biodeteriogens that can be of use for the conservation of road artefacts; (II) potential use of the plants of the investigated communities for the sustainable design of environmental redevelopment interventions or mitigation measures (e.g., for excavations, rock cuts, cut slopes, fill slopes, walls, etc.).

Materials and methods

Study area

The road system under investigation climbs up Monte Pellegrino (606 m a.s.l.), a well-known limestone mountain that rises to the northwest of Palermo in the northern coastal belt of Sicily (Hutchinson 1959). It has an elongated shape, with its major axes oriented from southeast to northwest, toward the Palermo plain. The topography is characterized by steep slopes and subvertical cliffs associated with subhorizontal planes (Fig. 1).

In terms of the geological setting, the study area is part of the Apennine–Maghrebian chain (Grasso, 2001). The lithostratigraphy is characterized by different formations described by Basilone (2018) within the Panormide carbonate platform successions (Upper Triassic to Lower Miocene), in particular, the following outcrops: a) the Pellegrino Formation (along the western side), that consists of massive rudistid boundstones and floatsones alternating with blackish laminated mudstone, stromatolitic and loferitic packstone, and bioclastic packstone; b) the Capo Gallo limestone formation (on the central part), that consists of well-stratified grey limestone (wackestone/packstone) alternating with blackish oolitic grainstone; c) the Piano Battaglia limestone formation (along the eastern and southern sides) that consists of massive grey reef limestones, calcareous breccias, and oolite grainstone; the Cozzo di Lupo formation that consists of Spongid reef limestones alternating with calcareous breccias and calcarenites (grainstone-packstone); d) scree and debris flow mainly concentrated along the sides of mountains (Basilone 2018).

In terms of climate, the study published by Duro et al. (1996) shows an average annual daytime temperature of 18.1 °C, while the average annual maximum temperature is 22.5 °C, and the average annual minimum temperature is 13.7 °C. The coldest month of the year is January (monthly mean minimum = 7.8 °C, monthly mean maximum = 15.7 °C), and the warmest month is August (monthly mean minimum = 20.8 °C, monthly mean maximum = 29.9 °C). Mean annual precipitation data (mm) on the Palermo plain, measured at different weather stations, show 679.4 mm (Istituto Castelnuovo), 643.7 mm (Servizio Idrografico) and 584.1 mm (Osservatorio Astronomico), corresponding to, respectively, 78, 73, and 71 rain days (Gianguzzi et al. 2013, 2015a).

Bioclimatic indices of the area, calculated according to Rivas-Martínez et al. (2011), allowed the definition of different thermotypes and ombrotypes in relation to land elevation as follows: a) Upper Thermomediterranean Lower Dry; b) Upper Thermomediterranean Upper Dry; c) Upper Thermomediterranean Lower Subhumid; d) Lower Mesomediterranean Lower Subhumid (Bazan et al. 2015; Gianguzzi et al. 2015b).

On the northern slopes, the local bioclimate tends to be Thermo-Mesomediterranean, from sub-humid to humid, due to the high cliffs shaped like a north-facing theater. Here, the vegetation consists of *Rhamno alaterni-Querco ilicis pistacio terebinthi* sigmetosum. In this vegetation series, the mature formation is a wood dominated by *Quercus ilex* and characterized by the presence of thermophilous deciduous broadleaves such as *Pistacia terebinthus* and *Rhus coriaria*. The seral stages are more frequently represented by maquis, dominated by the above-mentioned deciduous broadleaves and by perennial dry grasslands o *Helictotricho-Ampelodesmetum mauritanici* (Gianguzzi et al. 1996).

On the western and southwestern sides of Monte Pellegrino, contrasting microclimatic conditions, created by different slope aspects and steepness, result in a tendency towards the Thermomediterranean lower dry (also verging on the Inframediterranean). Climatophilous vegetation can be referred to the oleaster series (*Ruto chalepensis-Oleo sylvestris* sigmetum), whose head of series is the *Olea europaea* var. *sylvestris* xerophilous wood (Gianguzzi and Bazan 2019, 2020; Gianguzzi et al. 2020). The successional stages of the series are represented by *Euphorbia dendroides* garrigue (*Rhamno-Euphorbietum dendroidis* s.l.) and xerophilous *Hyparrhenia hirta* grassland (*Hyparrhenietum hirto-pubescentis* s.l.) which, in recent years, tends to be replaced by the alien invasive grassland Pennisetum setaceum (*Penniseto setacei-Hyparrenietum hirtae*), probably due to climate warming (Pasta et al. 2010). Communities dominated by therophytes (e.g. *Thero-Sedetum caerulei*, *Stipellula capensis* micro-communities, etc.) also belong to the same vegetation series.

On the eastern sides, the bioclimate is Thermomediterranean and ranges from upper dry to lower subhumid (north-east). Climatophilous vegetation is represented by a more xerophilous holm oak series (*Rhamno alaterni-Querco ilicis pistacio lentisci* sigmetosum) in which *Hyparrhenia hirta* grassland (*Hyparrenietum hirtae* s.l.) is the most significant and widespread degradation aspect.

The three climatophilous series come into contact with the microgeosigmeta of the inland cliff communities of the alliance *Dianthion rupicolae* (*Asplenietea trichomanis*), such as *Scabioso creticae-Centaureetum ucriae* (Gianguzzi et al. 1996).

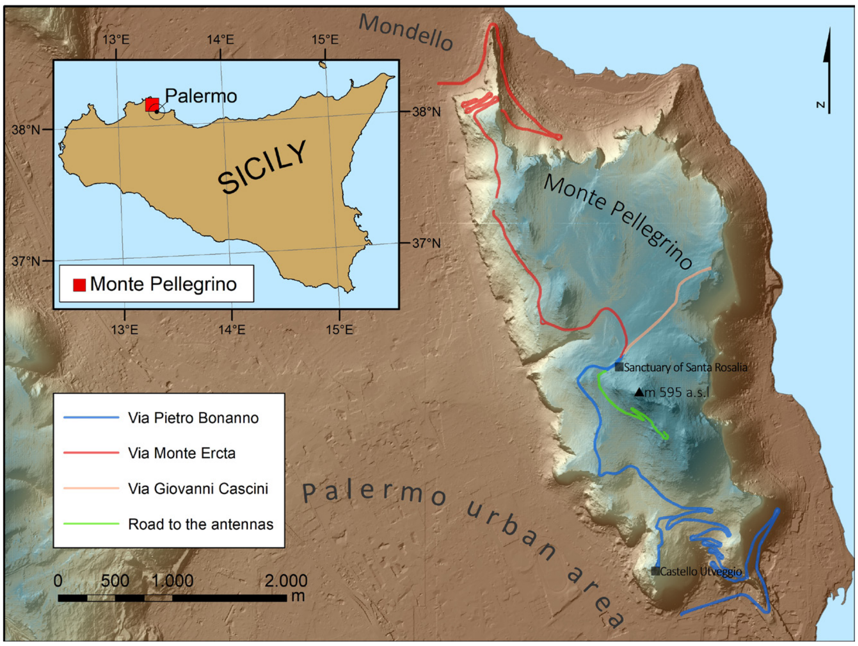

Figure 1. Location of the Monte Pellegrino road system.

Monte Pellegrino's vegetation mosaic hosts a rich flora, counting 741 infrageneric taxa (Raimondo et al. 1996), which includes some rupicolous endemic species and taxa of biogeographic interest, such as: *Iberis semperflorens*, *Glandora rosmarinifolia*, *Centaurea panormitana*, *Helichrysum panormitanum*, *Seseli bocconei*, *Micromeria fruticulosa* and *Brassica rupestris*.

Archaeological evidence in the Allaura caves (on the northern slopes of the mountain) dates the human presence in the area back to the Upper Paleolithic period (Mannino et al. 2011), testifying to a thousand-year-old exploitation of Monte Pellegrino's natural resources. Despite the historical land-use of the territory, the area has maintained a high level of biodiversity as a result of a long-term interaction between humans and nature, as has also been pointed out for other areas of Sicily (Guarino and Pasta 2017; Bazan et al. 2019, 2020; Musarella et al. 2018; Todaro et al. 2020).

However, due to its proximity to the city of Palermo, the protected area has been affected by anthropic disturbances, such as recurring fires, a prevalence (in terms of biomass) of exotic species over native ones, and waste dumping that afflicts even the most inaccessible areas, which damage the site's natural heritage.

Historical notes on the road system

The road system of Monte Pellegrino is located within the administrative area of the City of Palermo and, consequently, the roads are named following the toponyms of the urban streets. It is divided in four parts (Fig. 1), as follows: 1) via Pietro Bonanno, located on the southwestern side, connects the city of Palermo to the Sanctuary of Santa Rosalia; 2) via Monte Ercta (also called "Panoramica"), on the northwestern side, connects the Sanctuary of Santa Rosalia to the Mondello area; 3) via Giordano Cascini is the road between the Sanctuary and the panoramic lookout on the northeastern slope of the mountain; 4) a (nameless) service road that climbs from the Sanctuary to the antennas (578 m a.s.l.) on the top of the mountain.

The first two stretches of the road system, with a total length of 16 km, are the historical part of the road system. Via Pietro Bonanno is 9 km long and was named after the mayor who promoted its construction. It was designed at the end of the 19th century by the engineer Giuseppe Damiani Almeyda, who started construction in 1903 (Fundarò 1974; Barbera 2008), though it proceeded extremely slowly. After Almeyda's death in 1911, management was assigned to the engineer Carlo De Stefani who completed the work in 1924 (Bonanno 2002).

Due to the rugged morphology of the area, it was necessary to carry out large excavations in order to adapt the rocky terrain to the planned road layout. To level the road cross section, it was necessary to cut the rock and raise the lower part of the slopes using substantial masonry retaining walls along the entire route.

The second part of the road – via Monte Ercta – was built from Gabriele Ascione's design. The excavation works began in 1949, and the construction work was initiated in July 1952, lasting five years. The road was made following the same construction methods as the first part. However, being on the northwestern part of the mountain where the slopes are steeper, it was necessary to build even higher retaining walls, especially in the tight curves above Mondello.

At the same time, the area was reforested with non-native species, especially conifers from the genus *Pinus* (*P. halepensis*, *P. pinea*, etc.) and *Cupressus* (*C. sempervirens*, *C. arizonica*, etc.), as well as broad-leaved trees of the genus *Eucalyptus* (*E. camaldulensis*, *E. globulus*, *E. gomphocephala*, etc.) and other species (*Robinia pseudacacia*, *Ailanthus altissima*, etc.).

In some cases, reforestation influenced the vegetation colonizing the base of the retaining walls by creating shady conditions. In the period between 1927 and 1933, other exotic species were also introduced into the area, such as *Agave americana*, *A. sisalana*, *Opuntia ficus-indica*, and *O. maxima*, which spontaneously spread between the escarpments and the reforested parts, sometimes forming hedges along the road margins, especially on the xeric slopes facing south/southwest, such as near Castello Utveggio.

Habitats of the roadway structures

The ecological conditions of the anthropogenic micro-habitats created by the construction of the road system reflect the adaptive specialization of the species and plant communities that have settled in them. The studied plant communities were distributed in relation to the following drivers: a) topographical characteristics of the surfaces (horizontal on the road margins, more or less vertical on the walls and rock walls); b) nature of the substrate (stone walls with mortar, asphalt, rocky outcroppings), which generally presents soil poverty, alkaline pH (given the nature of the lithic materials), a lack of nutrients, poor humidity; c) various climatic stresses (e.g., daily and annual temperature ranges, etc.).

Figure 2 shows a cross-section of the roadway on Monte Pellegrino with the different habitats within which the vegetation surveys were carried out. Specifically, these were masonry retaining walls, downhill-side road margins (parapets/guardwalls), uphill-side road margins, artificial rock cuts. For each of the habitats presented in the figure, the main structural and ecological characteristics are defined below, also in relation to the eco-morphological and physiological characteristics of the species and coenoses located there.

1) *Retaining walls* – These continuously delimit the downhill side of the entire road route, with a height ranging from a few meters up to about 20 m (along the hairpin bends near Mondello). They are made of stone blocks cemented with mortar, built with a (a) base plinth, (b) sloping face, (c) and vertical face. Here lithophilous species,

whose roots penetrate the cracks and cavities between the stone blocks, have different settling difficulties, depending on the topographical location (Lisci and Pacini 1993a, 1993b). Cavities at ground level in the base plinth allow the establishment of numerous species, facilitated by the rainwater that flows down the walls, favoring the accumulation of nutrients and moisture needed by plants. Cavities on the sloping faces of the walls also facilitate the germination of seeds thanks to the rainwater that runs down the walls. Cavities on the vertical faces, instead, present greater settling difficulties – in particular on the higher parts and on homogeneous material – given the lower availability of water and nutrients.

2) *Masonry guardwalls (downhill side of the road)* – Here vegetation finds space in two different types of cavities in which accumulations of soil and humidity are generated. They are respectively located: a) on the upper surface of the guardwalls, following the crumbling of the materials due to the weather; b) at the base of the guardwall, at the interface between two types of construction materials (both inside and outside the road surface) which generates a certain water availability in the interstices.

3) *Road margins (uphill side)* – This habitat is located beyond the rainwater collection canals which have more nitrophilic and cooler ecological characteristics than the previous habitat. In fact, vegetation finds more favorable conditions here as there is more shade as well as a greater supply of nutrients and humidity thanks to the rainwater that flows down the slopes and walls above.

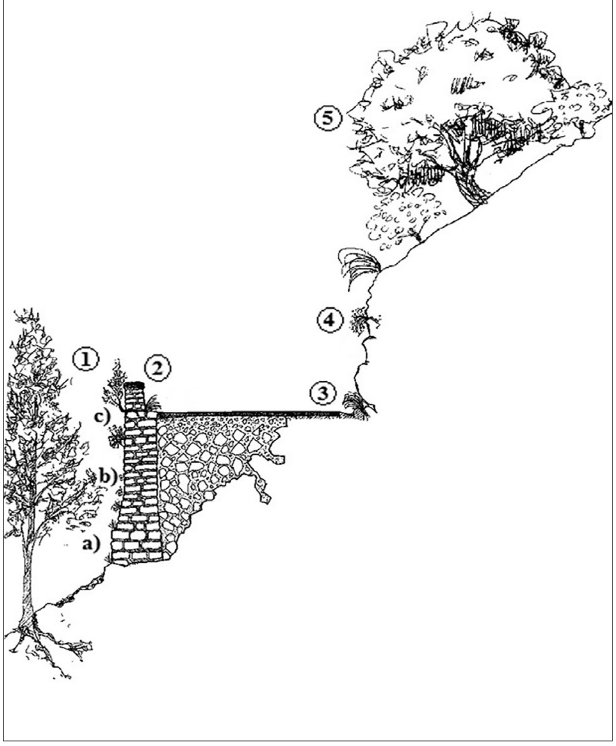

Figure 2. Cross-section of the habitat of the Monte Pellegrino road system: 1) retaining wall (a – base plinth; b – sloping face; c – vertical face); 2) downhill-side road margin (masonry guardwalls or parapets); 3) uphill-side road margin; 4) rock cut slopes, 5) natural slope.

4) *Rock cut slopes* – These delimit the uphill part of the road margins and were created by excavating the limestone substrate. They are up to about 15 meters high (on some curves on the Mondello side), giving space to typically rocky communities that develop along the rock walls, according to ecological gradients that can be attributed to purely natural environments. In the upper part, they are true chasmophytic communities dominated by species of the *Asplenietea trichomanis* class, replaced towards the base of the walls by elements attributable to the *Parietarietea judaicae* class.

5) *Natural slopes* – This habitat, completely unrelated to the road profile, is colonized by phytocenotic vegetation linked to the different vegetation series that characterize the Monte Pellegrino promontory (Gianguzzi et al. 1996), not examined in this work.

Vegetation sampling and data analysis

The vegetation was studied according to the phytosociological method (Braun-Blanquet 1964), as later modified by other authors (e.g., Rivas-Martínez 2005; Biondi 2011; Guarino et al. 2018). Species identifications were made using Pignatti (1982) and Pignatti et al. (2017-2018). Taxonomic nomenclature follows “Flora d'Italia” (Pignatti et al. 2017-2018), with the exception of *Pennisetum setaceum*, which follows the online database “The Plant List” (2013). The life forms and chorotypes follow Pignatti (1982).

The syntaxonomical nomenclature follows the “International Code of Phytosociological Nomenclature” (Theurillat et al. 2020). For the definition of the syntaxa, the “Vegetation Prodrome of Italy” (Biondi et al. 2014) was followed (see the specific interactive site: http://www.prodromo-vegetazione-italia.org/), with reference to the Vegetation Prodrome of Europe (Mucina et al. 2016) for the classes *Cymbalario-Parietarietea diffusae*, *Stipo-Trachynietea distachyae* and the order *Elytrigio repentis-Dittrichietalia viscosae*.

The survey, carried out between 2016 and 2019, was based on stratified random sampling. The study area was divided into different homogeneous ecological contexts based on both construction typology (masonry retaining wall, guardwall, uphill-side road margin, artificial rock cut slope) and exposition (north, west/southwest), and random sampling was conducted within each of these habitats (Michalcová et al. 2011). Plot size was determined as minimum area (*sensu* Braun-Blanquet 1964) and ranged between 5 and 50 m² in the different vegetation types. The number of relevés was defined on the basis of the micro-habitat's surface area. In the case of some groupments with a very small range on homogeneous surfaces, only 2-4 relevés were done.

To evaluate the distribution pattern of the habitats studied in terms of their specific composition, we used detrended correspondence analysis (DCA; Hill and Gauch

1980) using the RStudio (Version 1.1.463) free software and some functions of the vegan package (Oksanen 2015). The choice of this ordination method was confirmed by the measure of the so-called turnover (or SD units) of DCA, which corresponds to the length of its first ordination axes. Moreover, turnover represents a measure of a community's beta diversity. According to Lepš and Šmilauer (2003), it is preferable to use a unimodal method like DCA for values of turnover units greater than 3.7.

Similarity among different phytocoenoses was evaluated using the "Jaccard Index" (Jaccard 1908). Nestedness was calculated as the average co-occurrence of species, the 'a' component of the "Jaccard Index" (Tsakalos et al. 2018).

The life form analysis of the data in the phytosociological table was made by establishing: the percentage distribution of presence in the species list (flora); the percentage distribution of presence in the relevés (frequency), the percentage distribution of the coverage value in the relevés (cover).

Results

Communities on masonry retaining walls

Cl.: *CYMBALARIO-PARIETARIETEA DIFFUSAE* Oberd. 1969
Perennial vegetation with hemicryptophytes, nitrophilous and synanthropic, chasmo-comophytic, found on rocky walls and cliffs.

Ord.: *TORTULO-CYMBALARIETALIA* Segal 1969
Chasmo-nitrophilous and thermophilous vegetation of built-up areas of the Mediterranean and Atlantic, mild winter to subcontinental regions of temperate Europe, the Middle East, and North Africa.

All.: *GALIO VALANTIAE-PARIETARION JUDAICAE* Rivas-Mart. ex O. de Bolòs 1967
Thermomediterranean chasmophytic vegetation of limestone walls of the Iberian Peninsula and the western Tyrrhenian archipelago.

1) *CREPIDO BURSIFOLIAE-PARIETARIETUM JUDAICAE* ass. nov.

Phytosociological data: Table 1.

Holotypus: Rel. 6, Table 1.

Diagnostic species: *Parietaria judaica* (dom.), *Mercurialis annua*, *Oxalis pes-caprae*, *Crepis bursifolia*, *Erigeron bonariensis*.

Floristic-syntaxonomical notes: Based on the interpretation of various authors (Bartolo and Brullo 1986; Brullo and Guarino 2002), similar characteristics of wall vegetation have been attributed to the *Oxalido corniculatae-Parietarietum judaicae* association (Br.-Bl. 1952) Segal 1969 [= *Parietarietum judaicae* (Arènes 1928) Oberd. 1977]. This syntaxon has been indicated for different areas of the Mediterranean region (Braun-Blanquet and Tüxen). 1952; de Bolós 1967; Rivas-Martínez 1960, 1969; Horvatić 1963; Bartolo and Brullo 1986; Oberdorfer 1977; Brullo and Guarino 1998, 2002; Brullo et al. 2020) as corresponding to the concept of "phytocoenon". In fact, *Oxalis corniculata* – one of the species that gives the name to the association – is a plant linked to trampled environments (Brullo and Guarino 2002). Therefore, we think that *Oxalido corniculatae-Parietarietum judaicae* should be subdivided into multiple geographic synvariants ("races géographiques") with more limited distribution. This is the case for the two associations proposed here in which, in their typical combinations, high-frequency local differential species were identified, though transgressive from the contiguous phytocoenoses.

Description: It is a hemicryptophytic, sciophilous-nitrophilous, paucispecific formation clearly dominated by *Parietaria judaica*, located on the lower part of walls. It tends to form a more or less continuous and lush belt of vegetation 40-60 (80) cm tall, that normally has coverage between 75-100% with a minimum area of 6-8 m². The phytocoenosis is subjected to high levels of eutrophication that occurs in wall cracks and interstices between materials (rocks, mortar, concrete, soil, etc.) of different chemical composition. Here, small accumulations of well-humidified and nitrified soil are created from the flow of rainwater on the wall, as well as from the contributions of internal circulation within the wall. Other associated species can be frequent but with low coverage values, some of which have their vegetative optimum in the winter-spring period (e.g., *Oxalis pes-caprae*) while others have it in the spring-summer period (es. *Erigeron bonariensis*, *Crepis bursifolia*, *Mercurialis annua*, etc.). In particular, *Oxalis pes-caprae*, a South-African species in expansion in the Mediterranean area, is an element of the *Stellarietea mediae* class; *Mercurialis annua* is a paleotemperate species, typical of manured fields and belonging to the *Stellarietea mediae* class; *Erigeron bonariensis* is native to tropical America and has almost become a cosmopolite species belonging to the *Chenopodion* (*Sisymbrietalia*, *Stellarietea mediae*) alliance; *Crepis bursifolia* is an endemic Italian species that is rather widespread in the Tyrrhenian area, typical of pavements, trampled environments, and road margins, and is also an element of the T*risetario-Crepidetum bursifoliae* association (*Polygono-Poetea annuae*).

Syndynamism: This phytocoenosis plays a pioneering role at the base of masonry and rock walls and takes part in the shady-mesic geosigmetum (north-northwestern-facing slope) of the road system in question (Fig. 3A). It is rarer on the southern part of Monte Pellegrino where it is located on the north-facing walls of via Bonanno (Fig. 4A).

The association is in contact with: (a) the vegetation of horizontal surfaces, such as trampled areas (cl. *Polygono-Poetea annuae*), flower beds, cultivated areas (cl. Stellarietea mediae), as well as serial aspects of the slope vegetation of *Rhamno-Querco ilicis* sigmetum; (b) vegetation on the tops of walls, dominated by Parietaria judaica (*Athamanto siculae-Parietarietum judaicae* ass. nov.), *Hypochaeris laevigata* (*Helichryso panormitanae-Hypo-*

Table 1. *Crepido bursifoliae-Parietarietum judaicae* ass. nov.

Relevé (n°)	1	2	3	4	5	6*	7	8	9	10	11	12	
Altitude (m)	20	20	20	25	30	50	80	330	340	420	425	430	
Slope (°)	5	3	5	5	5	2	2	5	4	2	5	5	
Aspect	N	N	NE	E	E	N	NE	W	NW	NW	NW	NW	
Area (m²)	8	6	6	5	4	8	6	10	5	8	8	6	
Total cover (%)	100	90	100	100	100	90	100	85	95	100	100	100	
Average height (cm)	50	50	45	45	45	40	50	40	50	45	45	50	
Species per relevé	8	9	8	7	6	12	14	8	9	13	11	9	Presence
Characteristic and differential species of association													
Parietaria judaica L.	5	4	5	5	5	5	5	4	5	5	5	5	12
Mercurialis annua L.	.	.	+	.	+	.	+	+	.	2	1	+	7
Crepis bursifolia L.	1	+	+	+	.	+	+	.	.	+	+	+	9
Erigeron bonariensis L.	.	+	+	+	+	1	+	.	+	.	.	.	7
Oxalis pes caprae L.	.	.	+	.	.	+	.	+	1	.	+	.	5
Char. of the alliance													
Antirrhinum siculum Mill.	+	1	1	+	+	+	1	1	1	.	.	.	9
Hyoscyamus albus L.	.	+	.	2	1	.	.	.	.	.	.	.	3
Reichardia picroides (L.) Roth	.	.	.	.	.	.	.	.	+	.	+	.	2
Char. of the order and class													
Sonchus tenerrimus L.	2	+	+	.	2	+	+	.	+	+	+	1	10
Umbilicus horizontalis (Guss.) DC.	.	.	.	.	.	.	+	.	+	+	+	+	5
Ceterach officinarum Willd.	.	.	.	.	.	.	.	+	+	.	.	.	2
Cymbalaria muralis G.Gaertn., B.Mey. et Scherb.	+	.	.	.	.	.	.	.	.	.	.	.	1
Sedum dasyphyllum L. subsp. *dasyphyllum*	.	.	.	.	.	.	.	.	.	+	.	.	1
Other species													
Piptatherum miliaceum (L.) Coss.	1	.	+	.	.	1	.	.	.	.	.	.	3
Poa annua L.	.	1	.	.	.	1	+	.	.	.	.	.	3
Hordeum murinum subsp. *leporinum* (Link) Arcang.	.	.	.	.	.	1	.	.	.	+	+	.	3
Dactylis glomerata L.	.	.	.	.	.	.	+	.	.	+	.	+	3
Briza maxima L.	.	.	.	.	.	.	+	.	.	+	.	+	3
Lagurus ovatus L. subsp. *ovatus*	.	.	.	.	.	.	+	.	.	.	+	+	3
Hirschfeldia incana (L.) Lagr.-Foss. subsp. *incana*	+	.	.	.	.	+	.	.	.	.	.	.	2
Polycarpon tetraphyllum (L.) L.	.	.	.	.	.	+	1	.	.	.	.	.	2
Campanula erinus L.	.	.	.	.	.	.	.	+	+	.	.	.	2
Solanum villosum Mill.	.	.	.	.	.	.	1	.	.	.	.	1	2
Scrophularia peregrina L.	1	.	.	.	.	.	.	.	.	.	.	.	1
Polygonum aviculare L.	.	+	.	.	.	.	.	.	.	.	.	.	1
Boerhavia repens L.	.	+	.	.	.	.	.	.	.	.	.	.	1
Sisymbrium officinale (L.) Scop.	.	.	.	2	.	.	.	.	.	.	.	.	1
Dysphania ambrosioides (L.) Mosyakin et Clemants	.	.	.	1	.	.	.	.	.	.	.	.	1
Cynodon dactylon (L.) Pers.	.	.	.	.	.	1	.	.	.	.	.	.	1
Ailanthus altissima (Mill.) Swingle	.	.	.	.	.	.	+	.	.	.	.	.	1
Allium subhirsutum L.	.	.	.	.	.	.	.	1	.	.	.	.	1
Avena barbata Pott ex Link	.	.	.	.	.	.	.	+	.	.	.	.	1
Polypodium cambricum L.	.	.	.	.	.	.	.	.	.	1	.	.	1
Vicia villosa subsp. *varia* (Host) Corb.	.	.	.	.	.	.	.	.	.	+	.	.	1
Lolium perenne L.	.	.	.	.	.	.	.	.	.	+	.	.	1
Clinopodium nepeta (L.) Kuntze	.	.	.	.	.	.	.	.	.	+	.	.	1
Acanthus mollis L. subsp. *mollis*	.	.	.	.	.	.	.	.	.	.	+	.	1
Bromus sterilis L.	.	.	.	.	.	.	.	.	.	.	+	.	1

chaeridetum laevigatae ass. nov.), and *Lomelosia cretica* (*Scabioso-Centauretum ucriae*).

Synchorology: The association, quite common in the study area, probably has a wider distribution in Sicily and the Tyrrhenian area.

2) *ATHAMANTO SICULAE-PARIETARIETUM JUDAICAE* ass. nov.

Phytosociological data: Table 2.

Holotypus: Rel. 3, Table 2.

Diagnostic species: *Parietaria judaica* (dom.), *Athamanta sicula*, *Antirrhinum siculum*, *Campanula erinus*.

Description: It is a hemicryptophytic, sciophilous-nitrophilous, paucispecific formation, clearly dominated by *Parietaria judaica*, typical of cool and shady upper parts of walls (Fig. 3B). The association prefers the parts of walls with less eutrophication which mainly benefit from humidity and humus generated by percolation inside the embankment. Very few other species of *Parietarietea* (*Ceterach officinarum*, *Antirrhinum siculum*, etc.)

Table 2. *Athamanto siculae-Parietarietum judaicae* ass. nov.

Relevé (n°)	1	2	3*	4	5	6	Presence
Altitude (m)	150	170	410	410	417	420	
Slope (°)	95	95	95	70	70	80	
Aspect	SE	E	N	N	N	N	
Area (m²)	8	6	6	10	8	10	
Total cover (%)	60	65	70	70	70	80	
Average height (cm)	30	35	40	45	40	40	
Species per relevé	11	14	9	10	8	8	
Characteristic and differential species of association							
Parietaria judaica L.	3	3	3	3	3	2	6
Athamanta sicula L.	.	1	+	1	+	1	5
Campanula erinus L.	2	1	1	+	+	+	6
Char. of the alliance							
Antirrhinum siculum Mill.	1	1	.	+	.	+	4
Hyoseris radiata L.	1	1	+	.	+	+	5
Char. of the order and class							
Sonchus tenerrimus L.	+	+	1	.	.	+	4
Umbilicus horizontalis (Guss.) DC.	+	+	.	1	+	+	5
Hypochaeris laevigata (L.) Ces., Pass. et Gibelli	.	+	1	+	1	.	4
Ceterach officinarum Willd.	+	1	.	+	+	.	4
Cymbalaria muralis G.Gaertn., B.Mey. et Scherb.	.	.	+	.	.	.	1
Other species							
Lagurus ovatus L. subsp. *ovatus*	+	.	+	+	.	.	3
Pinus halepensis Mill.	+	+	.	.	.	.	2
Trachynia distachya (L.) Link	+	+	.	.	.	.	2
Pennisetum setaceum (Forssk.) Chiov.	+	+	.	.	.	.	2
Asphodelus ramosus L. subsp. *ramosus*	.	+	.	.	.	.	1
Allium subhirsutum L.	.	.	.	1	.	.	1
Musci	.	1	1	1	2	1	5

are associated, except for *Athamanta sicula* (an endemic chasmophyte of the class *Asplenietea trichomanis*) and *Campanula erinus* (a therophyte species of the alliance *Valantio-Galion muralis*, order *Geranio-Cardaminetalia*), all with very sporadic presence. The elements of trampled areas, ruderal areas, and road margins (classes *Polygono-Poetea annuae*, *Stellarietea mediae* and alliance *Bromo-Oryzopsion*) that characterize the vegetation developing at the bases of walls (described above), are missing.

Syndynamism: The association plays a pioneer role in the colonization of walls and takes part in the shady-mesic geosigmetum of the Monte Pellegrino road system where it is north-facing.

It establishes the following contacts: a) *Crepido bursifoliae-Parietarietum judaicae* ass. nov. (lower parts of the walls); b) *Diantho siculae-Helichrysetum panormitani* ass. nov. (exposed parts of older, higher walls).

Synchorology: The phytocoenosis is frequent in the study area and probably has a wider distribution in Sicily and the Tyrrhenian area.

3) *HELICHRYSO PANORMITANAE-HYPOCHAERIDETUM LAEVIGATAE* ass. nov.

Phytosociological data: Table 3.

Holotypus: Rel. 3, Table 3.

Diagnostic species: *Hypochaeris laevigata* (dom.), *Helichrysum panormitanum*, *Antirrhinum siculum*.

Description: It is a chamaephytic-hemicryptophytic, sciophilous-nitrophilous formation dominated by *Hypochaeris laevigata* and associated, among other species, with the endemic *Helichrysum panormitanum* and *Antirrhinum siculum*, which are differentials of the phytocoenosis (Fig. 3C). In its typical aspect, the association is widespread mainly in the first 4-6 meters of rock and masonry walls, in cool and shaded areas of north-facing surfaces.

Syndynamism: The association plays a pioneer role in the colonization of walls and takes part in the shady-mesic geosigmetum of the road system. It establishes catenal contacts with the following coenoses: a) *Athamanto siculae-Parietarietum judaicae* ass. nov. (middle part of walls); b) *Centranthetum rubri* (less exposed vertical parts of walls); c) *Diantho siculae-Helichrysetum panormitani* ass. nov. (exposed parts of old higher walls).

Synchorology: The association was observed along the northern slope of Monte Pellegrino, but presumably it is present in other similar contexts of the mountains of the Palermo area.

4) *CENTRANTHETUM RUBRI* Oberd. 1969

Phytosociological data: Table 4.

Lectotypus: Rel. 16, Table 1, Oberdorfer (1969).

Diagnostic species: *Centranthus ruber* (dom.).

Description: It is a chasmo-nitrophilous heliophilous coenosis dominated by *Centranthus ruber* and located in

Table 3. *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov.

Relevé (n°)	1	2	3*	4	5	6	Presence
Altitude (m)	90	95	100	90	130	135	
Slope (°)	90	90	90	90	90	90	
Aspect	N	N/NE	N	N	N/NW	N	
Area (m²)	10	20	8	20	10	20	
Total cover (%)	30	40	35	30	30	30	
Average height (cm)	30	30	35	20	30	35	
Species per relevé	19	22	16	13	19	17	
Characteristic and differential species of association							
Hypochaeris laevigata (L.) Ces., Pass. et Gibelli	3	3	3	2	2	3	6
Helichrysum panormitanum Guss. subsp. *panormitanum*	+	1	1	.	1	1	5
Antirrhinum siculum Mill.	+	+	+	.	+	.	4
Char. of the alliance, order and class							
Parietaria judaica L.	2	1	1	1	1	1	6
Centranthus ruber (L.) DC.	+	1	+	1	+	+	6
Umbilicus horizontalis (Guss.) DC.	1	+	+	.	+	+	5
Anogramma leptophylla (L.) Link	+	+	+	+	.	+	5
Ceterach officinarum Willd.	+	+	.	.	+	.	3
Hyoseris radiata L.	.	.	+	.	.	+	2
Reichardia picroides (L.) Roth	.	.	.	.	+	.	1
Transgressive species of the class *Asplenietea trichomanis*							
Polypodium cambricum L.	1	1	.	+	+	1	5
Dianthus rupicola Biv.	.	1	1	.	.	1	3
Iberis semperflorens L.	.	1	.	.	+	1	3
Cymbalaria pubescens (C.Presl) Cufod.	.	.	1	.	1	.	2
Athamanta sicula L.	.	1	.	.	.	.	1
Transgr. of the class *Quercetea ilicis*							**0**
Allium subhirsutum L.	1	1	1	.	+	1	5
Pistacia terebinthus L. subsp. *terebinthus*	+	1	1	.	.	.	3
Rhamnus alaternus L. subsp. *alaternus*	1	1	1	.	.	.	3
Prasium majus L.	1	.	.	.	+	1	3
Artemisia arborescens L.	+	.	+	.	.	.	2
Arisarum vulgare O.Targ.Tozz.	+	.	.	.	1	.	2
Ampelodesmos mauritanicus (Poir.) T.Durand et Schinz	.	1	.	.	.	1	2
Selaginella denticulata (L.) Spring	.	.	.	1	+	.	2
Euphorbia dendroides L.	.	.	.	1	.	.	1
Other species							
Campanula erinus L.	1	+	1	1	.	1	5
Theligonum cynocrambe L.	1	1	1	+	+	+	6
Mercurialis annua L.	1	+	.	.	.	+	3
Carlina sicula Ten.	+	.	.	.	.	1	2
Galium murale (L.) All.	.	1	.	1	.	.	2
Oxalis pes caprae L.	.	1	.	.	1	.	2
Hypochaeris achyrophorus L.	.	.	.	+	+	.	2
Valantia muralis L.	.	1	.	.	.	.	1
Geranium lucidum L.	.	.	.	+	.	.	1
Stellaria neglecta Weihe subsp. *neglecta*	.	.	.	+	.	.	1
Micromeria fruticulosa (Bertol.) Šilić (Bertol.) Guinea	.	.	.	.	+	.	1

the upper parts of less exposed walls and other masonry structures. The association prefers cooler habitats where it benefits from a certain amount of edaphic humidity due to water percolation inside the embankment.

Syndynamism: In the local area, this phytocoenosis belongs to the shady-mesic geosigmetum of the north-facing slope of the promontory located, in particular, on the more sheltered walls of the hairpin bends of Contrada Allaura. The association establishes catenal contacts with the following coenoses: a) *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov. (near the base of old walls shaded by tree foliage); b) *Diantho siculae-Helichrysetum panormitani* ass. nov. (exposed upper parts of old walls, above 6-8 m); c) groupment with *Rhamnus alaternus* and *Pistacia terebinthus* (upper parts of walls at 4-6 m).

Synchorology: The association is spread across the Mediterranean area in the thermomediterranean and lower mesomediterranean bioclimatic belts, and is present in Sicily to some extent (Brullo and Guarino 2002). It is not frequent in the study areas, where it is only located on the northern slopes.

Table 4. *Centranthetum rubri* Oberd. 1969.

Relevé (n°)	1	2	3	4	Presence
Altitude (m)	90	95	90	95	
Slope (°)	90	90	90	90	
Aspect	N	N/NE	N	N/NE	
Area (m^2)	20	20	20	20	
Total cover (%)	50	45	50	45	
Average height (cm)	40	45	40	45	
Species per relevé	12	10	14	12	
Guide species					
Centranthus ruber (L.) DC.	3	3	3	3	5
Char. of the class *Parietarietea judaicae*					
Hypochaeris laevigata (L.) Ces., Pass. et Gibelli	1	2	1	1	4
Parietaria judaica L.	1	+	1	1	4
Ceterach officinarum Willd.	+	+	+	+	4
Antirrhinum siculum Mill.	1	.	1	+	3
Umbilicus horizontalis (Guss.) DC.	.	+	+	+	3
Transgr. of the class *Asplenietea trichomanis*					
Dianthus rupicola Biv.	.	1	+	1	3
Helichrysum panormitanum Guss.	.	1	.	1	2
Other species					
Campanula erinus L.	1	+	1	+	4
Galium murale (L.) All.	2	1	2	2	4
Allium subhirsutum L.	1	1	+	1	4
Hypochaeris achyrophorus L.	+	.	+	+	3
Euphorbia dendroides L.	1	.	1	.	2
Arisarum vulgare O.Targ.Tozz.	+	.	+	.	2
Selaginella denticulata (L.) Spring	+	.	+	.	2

5) *ANTIRRHINETUM SICULI* Bartolo & Brullo 1986

Phytosociological data: Table 5.

Holotypus: Rel. 2, Table 3, Bartolo & Brullo (1986).

Diagnostic species: *Antirrhinum siculum* (dom.).

Description: It is a chasmo-nitrophilous paucispecific formation with an open structure, heliophilous and thermo-xerophilous, dominated by *Antirrhinum siculum* (Fig. 4B), an endemic species of Sicily and southern Italy, adapted to growing on masonry structures. The phytocoenosis mainly colonizes the upper parts of xeric stone, where it is located in poorly humified cracks.

Syndynamism: The phytocoenosis belongs to the more xeric geosigmetum of the study areas, where it is found mostly on the southern and western slopes. It comes into catenal contact with the following associations: a) *Olopto miliacei-Pennisetetum setacei* ass. nov. (both at the base of the walls and on the upper parts, in particular on guardwalls); b) *Capparidetum rupestris* (in the upper parts of some walls); *Rhamno alaterni-Euphorbietum dendroidis* Géhu and Biondi 1997 *artemisietosum arborescentis* subass. nov. (guardwalls of sunny and sheltered walls).

Synchorology: The association is endemic in the southern parts of the Italian Peninsula (Brullo et al. 2001; Brullo and Guarino 2002), Sicily (Bartolo and Brullo 1986; Gianguzzi 2007), and Malta (Brullo et al. 2020).

All.: *ARTEMISIO ARBORESCENTIS-CAPPARIDION SPINOSAE* Biondi, Blasi et Galdenzi in Biondi et al. 2014

Thermomediterranean chasmophytic vegetation of limestone walls of the Apennine Peninsula, Corsica, Sardinia, Sicily, and Malta.

6) *CAPPARIDETUM RUPESTRIS* O. Bolòs et Molinier 1958

Lectotypus: Rel. 1, Table18, Bolòs & Molinier (1958).

Phytosociological data: Table 6.

Diagnostic species: *Capparis spinosa* (dom.).

Description: It is a chasmo-nitrophilous paucispecific formation with an open structure, heliophilous and xerophilous, dominated by large bushes of *Capparis spinosa*, typical of calcareous rocks and masonry walls (Fig. 4C). The phytocoenosis occupies the upper parts of old masonry walls and rock walls where it is located in sunny and xeric positions which are more or less sheltered and nitrified. In the road system investigated, it has mostly colonized the artificial rock slopes created by cutting into the limestone, in particular in the upper parts, over 4-5 m high on south-facing aspects.

Syndynamism: The phytocoenosis is a mature, permanent vegetation that grows on the most xeric geosigmetum of walls, located mostly on the southern slopes of the promontory. Here, it establishes catenal contacts with the following coenoses: a) *Olopto miliacei-Pennisetetum setacei* ass. nov. (both at the base of the walls and on the upper parts, in particular on the guardwalls); b) *Antirrhinetum siculi* (on the upper parts of some walls); c) *Rhamno alaterni-Euphorbietum dendroidis* Géhu & Biondi 1997 *arte-*

Table 5. *Antirrhinetum siculi* Bartolo & Brullo 1986.

Relevé (n°)	1	2	3	4	5	
Altitude (m)	570	550	350	330	550	
Slope (°)	90	90	90	90	90	
Aspect	S	SW	S	W	SW	
Area (m²)	5	5	4	5	5	
Total cover (%)	45	50	50	50	45	
Average height (cm)	20	20	20	20	20	
Species per relevé	18	14	15	12	15	Presence
Guide species						
Antirrhinum siculum Mill.	3	2	3	2	2	5
Char. of the alliance, order and class						
Umbilicus horizontalis (Guss.) DC.	1	1	+	1	1	5
Ceterach officinarum Willd.	1	.	1	1	+	4
Transgr. of the class *Tuberarietea guttatae*						
Misopates orontium (L.) Raf.	+	+	+	1	+	5
Carduus pycnocephalus L.	1	+	1	1	+	5
Hypochaeris achyrophorus L.	1	+	1	+	+	5
Avena barbata Pott ex Link	1	+	1	.	+	4
Anisantha fasciculata (C.Presl) Nevski	+	+	+	.	+	4
Campanula erinus L.	1	1	.	1	1	4
Lagurus ovatus L. subsp. *ovatus*	+	+	.	.	+	3
Char. of the alliance, order and class						
Phagnalon saxatile (L.) Cass.	+	2	1	1	2	5
Pennisetum setaceum (Forssk.) Chiov.	1	1	+	1	1	5
Sonchus tenerrimus L.	1	1	+	+	1	5
Theligonum cynocrambe L.	+	+	1	+	+	5
Trifolium stellatum L.	1	.	1	1	.	3
Mercurialis annua L.	1	.	1	.	.	2
Echium parviflorum Moench	+	.	+	.	.	2
Euphorbia dendroides L.	.	1	.	.	1	2
Asparagus albus L.	+	.	.	.	.	1

misietosum arborescentis subass. nov. (on sunny and sheltered guardwalls).

Synchorology: The association, described by De Bolós and Molinier (1958), is widespread in the Mediterranean area (Brullo and Guarino 2002) and, as reported by several authors, specifically in Sicily (Bartolo and Brullo 1986; Brullo et al. 1993; Gianguzzi 2007) and on the islands of Lampedusa (Bartolo et al. 1990) and Pantelleria (Gianguzzi 1999). In the study areas, it is frequently found along the roads on the slope of Contrada Arenella (Gianguzzi et al. 1996).

Cl.: *ASPLENIETEA TRICHOMANIS* (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. 1977
Chasmophytic vegetation of crevices, rocky ledges and faces of rocky cliffs and walls of Europe, North Africa, the Middle East, Arctic archipelagos and Greenland.
Ord.: *ASPLENIETALIA GLANDULOSI* Br.-Bl. in Meier & Br.-Bl. 1934
Thermo-mesomediterranean chasmophytic vegetation of sunny calcareous rock faces and crevices of the western Mediterranean.
All.: *DIANTHION RUPICOLAE* Brullo & Marcenò 1979
Siculo-Calabrian Tyrrhenian coasts and the islands of Malta.

7) *DIANTHO SICULAE-HELICHRYSETUM PANORMITANI* Gianguzzi ass. nov.
Phytosociological data: Table 7.
Holotypus: Rel. 5, Table 7.
Diagnostic species: *Helichrysum panormitanum* subsp. *panormitanum* (dom.), *Dianthus rupicola*, *Micromeria fruticulosa*, *Antirrhinum siculum*.

Floristic-syntaxonomical notes: *Helichrysum panormitanum* Guss. subsp. *panormitanum* (= *H. rupestre* (Raf.) DC. var. *panormitanum* (Guss.) Lojac.) is an endemic chasmophyte of the coastal capes to the west of Palermo, from Mt. Pellegrino to Castellammare del Golfo (Iamonico et al. 2016), which is linked to rupicolous environments in which it is considered an element of the *Dianthion rupicolae* alliance. The phytocoenosis in question is framed in the latter alliance, given the general physiognomy of vegetation clearly influenced by rupicolous species of the class *Asplenietea*. This is evident, above all, on the oldest walls which provide high and exposed cliff-like habitats.

Description: It is a chasmophilous, paucispecific, heliophilous, and mesophilous formation dominated by *Helichrysum panormitanum* subsp. *panormitanum*, typical of the highest parts of old walls, above 4-6 m. The association is located in sunny and xeric places which are not

Table 6. *Capparidetum rupestris* O. Bolòs et Molinier 1958.

Relevé (n°)	1	2	3	4	5	6	
Altitude (m)	90	92	150	180	6	6	
Slope (°)	85	85	90	90	90	90	
Aspect	E	E	E	E	N	NE	
Area (m²)	8	10	15	15	15	15	
Total cover (%)	60	55	60	50	40	30	
Average height (cm)	60	50	70	65	60	60	
Species per relevé	11	11	13	13	8	10	Presence
Characteristic and differentials species of association							
Capparis spinosa L.	3	3	3	3	2	2	6
Char. of the class *Parietarietea judaicae*							
Antirrhinum siculum Mill.	1	1	+	1	.	+	5
Hyoseris radiata L.	+	+	+	.	+	+	5
Parietaria judaica L.	1	1	.	+	+	+	5
Umbilicus horizontalis (Guss.) DC.	+	.	.	+	.	+	3
Sonchus tenerrimus L.	.	.	.	+	+	+	3
Ceterach officinarum Willd.	.	+	.	+	.	.	2
Hyoscyamus albus L.	.	.	.	.	1	1	2
Reichardia picroides (L.) Roth	.	.	+	.	.	.	1
Ficus carica L.	.	+	.	.	.	.	1
Transgr. of the class *Asplenietea trichomanis*							
Helichrysum panormitanum Guss.	2	1	1	1			4
Dianthus rupicola Biv.	1	2	1	1			4
Seseli bocconei Guss.	.	.	+	1			2
Phagnalon saxatile (L.) Cass.	+	1	.	.			2
Other species							
Pennisetum setaceum (Forssk.) Chiov.	1	1	.	.	+	+	4
Micromeria fruticulosa (Bertol.) Šilić	1	.	+	1	.	.	3
Campanula erinus L.	1	.	.	.	.	+	2
Sachys major (L.) Bartolucci et Peruzzi	.	.	1	+	.	.	2
Galium cinereum All.	.	.	+	1	.	.	2
Euphorbia dendroides L.	.	.	1	+	.	.	2
Symphyotrichum squamatum (Spreng.) G.L.Nesom	.	.	.	.	+	+	2
Valantia muralis L.	.	+	.	.	.	.	1
Lomelosia cretica (L.) Greuter et Burdet	.	.	1	.	.	.	1
Pinus halepensis Mill.	.	.	+	.	.	.	1
Fumaria capreolata L. subsp. *capreolata*	.	.	.	.	+	.	1

well nitrified, mainly on the north-facing walls and rarely on natural or artificial rocky cliffs. Species of the class *Parietarietea judaicae* (*Ceterach officinarum*, *Parietaria judaica*, *Antirrhinum siculum*, *Capparis spinosa*), with low coverage values, as well as several elements of the class *Asplenietea trichomanis* (*Dianthus rupicola*, *Lomelosia cretica*, *Matthiola incana* subsp. *rupestris*, *Seseli bocconei*, etc.) are associated with it. The community forms dense vegetation belts due to thick patches of the dominant species covering the cracks between the stone blocks.

Syndynamism: The association is well represented in the shady-mesic geosigmetum of the road stretches located in the north/northwest-facing slopes of the promontory. It establishes contacts with the following phytocoenoses: a) *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov. (at the base of walls shaded by the crowns of trees); b) *Centranthetum rubri* (at the base of sunny walls); c) *Rhamnus alaternus* and *Pistacia terebinthus* groupment (upper parts of the highest walls).

Synchorology: The phytocoenosis is spread along the entire road system of Monte Pellegrino, especially on the highest and most exposed stretches of the northern and western sides (via Monte Ercta).

Communities of rock cut slopes

8) *SCABIOSO CRETICAE-CENTAURETUM UCRIAE* Brullo et Marcenò 1979 subass. *TYPICUM*

Phytosociological data: Table 8.

Holotypus: Rel. p. 139, in Brullo et Marcenò (1979).

Diagnostic species: *Lomelosia cretica* (dom.), *Helichrysum panormitanum*, *Euphorbia bivonae* subsp. *bivonae*, *Centaurea panormitana* (= *C. ucriae* Lacaita), *Convolvulus cneorum*, *Dianthus rupicola*, *Seseli bocconei*, *Silene fruticosa*, *Iberis semperflorens*.

Description: It is a chasmophilous, heliophilous, and mesophilous formation, widespread on the upper parts of

Table 7. *Diantho rupicolae-Helichrysetum panormitani* Gianguzzi ass. nov.

Relevé (n°)	1	2	3	4	5*	6	7	8	9	10	11	12	13	14	15	Presence
Altitude (m)	150	110	150	160	186	190	160	170	150	180	330	330	300	300	270	
Slope (°)	90	90	90	85	85	85	90	90	90	90	85	90	85	85	85	
Aspect	N	N	N	N	NW	NW	E	E	E	E	W	W	SW	SW	W	
Area (m^2)	20	20	20	15	20	15	15	15	15	15	20	12	20	30	20	
Total cover (%)	55	55	50	55	60	60	50	50	55	60	65	60	60	60	50	
Average height (cm)	50	50	35	40	40	45	45	40	55	60	50	40	40	40	50	
Species per relevé	20	17	15	15	17	17	19	14	17	14	12	12	16	19	17	
Characteristic and differentials species of association																
Helichrysum panormitanum Guss.	2	3	3	3	3	3	2	3	2	3	3	3	3	3	2	15
Dianthus rupicola Biv.	1	.	1	1	1	.	1	+	1	1	1	+	1	1	1	13
Micromeria fruticulosa (Bertol.) Šilić	1	.	+	+	.	.	1	1	+	1	.	+	1	1	1	11
Antirrhinum siculum Mill.	+	+	.	+	+	+	.	.	+	1	+	1	.	.	.	9
Char. of the alliance *Dianthion rupicolae* and class *Asplenietea trichomanis*																
Lomelosia cretica (L.) Greuter et Burdet	1	+	.	+	1	+	1	1	1	+	1	+	.	1	1	13
Galium cinereum All.	+	.	.	1	+	1	+	+	+	+	.	+	.	+	.	10
Seseli bocconei Guss.	1	+	.	.	.	.	+	+	+	1	+	.	.	1	.	8
Phagnalon saxatile (L.) Cass.	1	+	1	.	.	+	.	.	+	.	.	.	1	+	1	8
Hypochaeris laevigata (L.) Ces., Pass. et Gibelli	+	1	1	+	1	1	.	.	+	.	.	.	.	.	.	7
Iberis semperflorens L.	+	1	+	1	.	.	.	.	.	.	.	.	.	1	.	5
Centaurea panormitana Lojac.	1	.	+	+	1	.	.	.	.	.	.	.	.	.	.	4
Matthiola incana (L.) W.T.Aiton subsp. *rupestris*	.	+	+	.	.	+	+	.	.	.	.	.	.	.	.	4
Silene fruticosa L.	1	.	.	.	.	.	.	.	.	.	+	.	+	.	.	3
Athamanta sicula L.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	2
Ballota hispanica (L.) Benth.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	2
Teucrium flavum L. subsp. *flavum*	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	2
Brassica rupestris Raf.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	2
Sedum dasyphyllum L. subsp. *dasyphyllum*	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	2
Coronilla valentina L.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1
Convolvulus cneorum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
Char. of the class *Parietarietea judaicae*																
Capparis spinosa L.	.	.	.	.	.	.	1	+	1	1	.	.	1	1	+	7
Pennisetum setaceum (Forssk.) Chiov.	.	.	.	.	.	.	1	1	1	1	.	1	1	1	.	7
Parietaria judaica L.	.	.	.	.	1	1	+	+	.	.	1	+	.	.	.	6
Sedum sediforme (Jacq.) Pau	.	.	.	.	.	.	.	+	.	+	.	+	+	1	+	6
Hyoseris radiata L.	+	.	.	.	+	.	+	.	.	.	+	.	.	.	.	4
Ceterach officinarum Willd.		1	.	.	.	.	.	.	.	.	+	1	+	.	.	4
Sonchus tenerrimus L.	.	.	+	.	.	+	.	+	.	+	.	.	.	.	.	4
Centranthus ruber (L.) DC.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	3
Umbilicus horizontalis (Guss.) DC.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1
Transgr. of the class *Quercetea ilicis*																
Ampelodesmos mauritanicus (Poir.) T.Durand et Schinz	+	.	1	+	.	1	.	.	.	.	.	.	+	.	+	6
Euphorbia dendroides L.	+	.	.	.	.	.	.	.	1	+	.	.	+	1	+	6
Prasium majus L.	.	.	.	+	+	+	1	.	+	+	.	.	.	.	.	6
Rhamnus alaternus L. subsp. *alaternus*	.	.	.	+	.	1	1	.	.	.	+	.	.	.	.	4
Artemisia arborescens L.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.	3
Pinus halepensis Mill.	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.	2
Emerus major Mill.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Cytisus infestus (C.Presl) Guss.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Asparagus acutifolius L.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1
Pistacia terebinthus L.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1
Euphorbia bivonae Steud. subsp. *bivonae*	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
Asparagus albus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1
Other species																
Campanula erinus L.	.	+	.	.	+	+	+	.	+	.	+	+	.	.	.	7
Bituminaria bituminosa (L.) C.H.Stirt.	.	.	1	.	.	1	+	.	.	.	.	.	+	1	1	6
Prospero autumnale (L.) Speta	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	4
Valantia muralis L.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	3
Reseda alba L.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	3
Reichardia picroides (L.) Roth	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	3
Mercurialis annua L.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	2
Allium subhirsutum L.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	2
Avena barbata Pott ex Link	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	2
Anthyllis maura Beck	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	2

Table 7. Continuation.

Relevé (n°)	1	2	3	4	5*	6	7	8	9	10	11	12	13	14	15	Presence
Altitude (m)	150	110	150	160	186	190	160	170	150	180	330	330	300	300	270	
Slope (°)	90	90	90	85	85	85	90	90	90	90	85	90	85	85	85	
Aspect	N	N	N	N	NW	NW	E	E	E	E	W	W	SW	SW	W	
Area (m^2)	20	20	20	15	20	15	15	15	15	15	20	12	20	30	20	
Total cover (%)	55	55	50	55	60	60	50	50	55	60	65	60	60	60	50	
Average height (cm)	50	50	35	40	40	45	45	40	55	60	50	40	40	40	50	
Species per relevé	20	17	15	15	17	17	19	14	17	14	12	12	16	19	17	
Dittrichia viscosa (L.) Greuter subsp. *viscosa*	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	2
Asphodelus ramosus L. subsp. *ramosus*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	2
Theligonum cynocrambe L.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Lobularia maritima (L.) Desv.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1
Echium plantagineum L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1
Charybdis maritima (L.) Speta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1
Trachynia distachya (L.) Link.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1

cliffs and rocky cut slopes, more or less shaded, dominated by *Lomelosia cretica*.

Syndynamism: Pioneer vegetation that plays an edaphoclimatic role in the colonization processes of fresh and humid artificial rocky cut slopes and natural cliffs. In fact, on slopes shaped by the excavation of limestone that have been left undisturbed, the chasmophytic association appears naturally restored. It is in catenal contact with the following associations: a) *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov. (at the base of shady and nitrified walls); b) *Olopto miliacei-Pennisetetum setacei* ass. nov. (at the base of sunny and xeric walls); grasslands associated with *Penniseteto setacei-Hyparrhenietum hirtae* and aspects of the *Ruto-Oleo sylvestris* sigmetum located on the slopes above the road system (Fig. 4D).

Synchorology: This phytocoenosis is frequent on the cliffs and cut slopes of Monte Pellegrino. It is also widespread in the mountains of Palermo and Trapani areas (up to 900 m a.s.l.) and has been reported for small and isolated locations in the Nebrodi Mountains at Rocche del Crasto (Brullo and Marcenò 1979).

Communities of masonry guardwalls

Cl.: *STIPO-TRACHYNIETEA DISTACHYAE* S. Brullo in S. Brullo et al. 2001
Mediterranean calciphilous annual and ephemeroid swards and grasslands

Ord.: *BRACHYPODIETALIA DISTACHYI* Rivas-Mart. 1978
Western Mediterranean ephemeral winter pastures on shallow sandy and loamy soils over limestone, dolomite, and gypsum.

All.: *HYPOCHOERIDION ACHYROPHORI* Biondi & Guerra 2008
Annual community, xerophytic, pioneer, basiphilous, of the European Central Mediterranean area in the thermomediterranean and mesotemperate bioclimatic belts. It is part of the *Trachynion distachyae* alliance of the western Mediterranean, and reaches its western distribution limit in the Mediterranean area around Provence.

9) Groupment with *STIPELLULA CAPENSIS*

Phytosociological data: Table 9.

Diagnostic species: *Stipellula capensis* (dom.).

Description: Therophytic heliophilous and xerophilous formation, with spring phenology, growing in the soil accumulated on the tops of old guardwalls on the road margin (parapets) due to deterioration caused by weathering events. The phytocoenosis is physiognomically dominated by *Stipellula capensis*, which is associated with other ephemeral species.

Syndynamism: Pioneer vegetation mainly related to the more xeric geosigmetum of the road system. It is in catenal contact with ruderal and wall formations, such as the *Olopto miliacei-Pennisetetum setacei* ass. nov.

Synchorology: *Stipellula capensis* vegetation is quite widespread in Sicily (Brullo et al. 2000; Gianguzzi and La Mantia 2008), although it has been little investigated from a phytosociological point of view.

Communities of road margins

Cl.: *ARTEMISIETEA VULGARIS* Lohmeyer et al. in Tx. Ex von Rochow1951
Perennial (sub)xerophilous ruderal vegetation of the temperate and submediterranean regions of Europe.

Ord.: *ELYTRIGIO REPENTIS-DITTRICHIETALIA VISCOSAE* Mucina in Mucina et al. 2016
Anthropogenic sub-ruderal and ruderal grasslands and herblands of submediterranean and Mediterranean Southern Europe.

All.: *BROMO-ORYZOPSION MILIACEAE* O. Bolòs 1970
Thermomediterranean sub-ruderal perennial grasslands on disturbed road margins of the Mediterranean.

10) *OLOPTO MILIACEI-PENNISETETUM SETACEI* Gianguzzi ass. nov.

Phytosociological data: Table 21 in Gianguzzi et al. 1996.

Figure 3. Shady-mesic slopes of the road system: **A** view of via Monte Ercta; **B** *Athamanto-Parietarietum judaicae*; **C** *Helichryso-Hypochaeridetum laevigatae*; **D** vegetation of the *Olopto-Pennisetetum setacei* (road margins) and *Diantho-Helichrysetum panormitanae* (walls); **E** vegetation of the *Teucrio flavi-Rhoetum coriariae*; **F** woody plants at the base of masonry guardwalls.

Figure 4. Xerophilous slopes of the road system: **A** view of via Bonanno; **B** *Antirrhinetum siculi*; **C** *Capparidetum rupestris*; **D** aspects of the series *Ruto-Oleo sylvestris* sigmetum; **E** *Olopto-Pennisetetum setacei* (road margins) and *Penniseto setacei-Hyparrhenietum* (slope); **F** vegetation of the *Rhamno-Euphorbietum dendroidis* subass. *artemisietosum arborescentis*.

Table 8. *Scabioso creticae-Centauretum ucriae* Brullo et Marcenò 1979 subass. *typicum*.

Relevé (n°)	1	2	3	4	5	6	7	Presence
Altitude (m)	47	165	170	180	250	330	330	
Slope (°)	88	85	90	90	90	85	90	
Aspect	NW	N	NW	NW	NW	W	W	
Area (m²)	20	40	30	40	20	30	20	
Total cover (%)	60	60	50	55	55	65	60	
Herbaceous cover (%)	25	25	25	25	25	25	25	
Average height (cm)	24	21	20	20	29	28	23	
Characteristic and differential species of association								
Lomelosia cretica (L.) Greuter et Burdet	3	3	3	3	3	3	3	7
Helichrysum panormitanum Guss.	2	2	2	1	2	+	+	7
Euphorbia bivonae Steud. subsp. *bivonae*	1	+	.	.	1	.	.	3
Centaurea panormitana Lojac.	1	.	.	1	.	.	.	2
Convolvulus cneorum L.	.	.	.	.	.	+	.	1
Char. of the alliance *Dianthion rupicolae* and class *Asplenietea trichomanis*								
Dianthus rupicola Biv.	1	1	1	+	2	1	1	7
Seseli bocconei Guss.	1	+	.	.	+	+	.	4
Phagnalon saxatile (L.) Cass.	+	.	1	1	1	1	1	6
Iberis semperflorens L.	+	+	1	+	1	.	.	5
Matthiola incana (L.) W.T.Aiton subsp. *rupestris*	1	+	1	+	1	.	.	5
Coronilla valentina L.	1	1	1	1	.	.	.	4
Brassica rupestris Raf.	1	1	.	1	1	.	.	4
Ballota hispanica (L.) Benth	+	.	.	.	1	1	+	4
Hypochaeris laevigata (L.) Ces., Pass. et Gibelli	.	1	1	1	.	.	+	4
Sedum dasyphyllum L. subsp. *dasyphyllum*	+	.	.	.	.	1	+	3
Silene fruticosa L.	.	.	.	.	1	1	1	3
Glandora rosmarinifolia (Ten.) D.C.Thomas	.	.	.	+	.	.	.	1
Teucrium flavum L. subsp. *flavum*	.	.	.	.	1	.	.	1
Transgr. of the class *Parietarietea*								
Ceterach officinarum Willd.	.	.	1	+	1	1	1	5
Antirrhinum siculum Mill.	.	+	1	+	+	.	.	4
Hyoseris radiata L.	+	.	.	.	.	1	+	3
Sedum sediforme (Jacq.) Pau	.	1	1	.	1	.	.	3
Umbilicus horizontalis (Guss.) DC.	.	+	.	.	1	.	1	3
Parietaria judaica L.	+	.	.	.	1	.	.	2
Capparis spinosa L.	1	.	.	.	.	.	.	1
Reichardia picroides (L.) Roth	.	.	.	.	+	.	.	1
Transgr. of the class *Quercetea ilicis*								
Euphorbia dendroides L.	1	1	1	.	.	1	+	5
Prasium majus L.	.	+	.	.	1	2	2	4
Asparagus acutifolius L.	+	.	.	.	.	+	1	3
Ampelodesmos mauritanicus (Poir.) T.Durand et Schinz	.	1	1	1	.	.	.	3
Allium subhirsutum L.	+	+	.	.	.	.	.	2
Rhamnus alaternus L. subsp. *alaternus*	.	.	.	.	.	1	1	2
Asparagus albus L.	.	.	.	.	.	+	+	2
Melica minuta L.	+	.	.	.	.	.	.	1
Cytisus infestus (C.Presl) Guss.	.	.	+	.	.	.	.	1
Artemisia arborescens L.	.	.	.	.	+	.	.	1
Other species								
Galium cinereum All.	1	1	+	+	1	.	.	5
Micromeria fruticulosa (Bertol.) Šilić	2	1	1	1	.	.	1	5
Bituminaria bituminosa (L.) C.H.Stirt.	1	.	.	+	.	1	1	4
Allium polyanthum Schult. et Schult.f.	.	1	1	+	+	.	.	4
Campanula erinus L.	.	.	.	.	+	+	1	3
Asphodelus ramosus L. subsp. *ramosus*	+	.	.	.	1	.	.	2
Prospero autumnale (L.) Speta	.	+	.	.	+	.	.	2
Elaeoselinum asclepium (L.) Bertol.	.	.	1	+	.	.	.	2
Calendula suffruticosa Vahl subsp. *fulgida* (Raf.) Guadagno	.	.	.	.	.	1	1	2
Echium parviflorum Moench	.	.	.	.	.	1	+	2
Hirschfeldia incana (L.) Lagr.-Foss. subsp. *incana*	.	.	.	.	.	+	+	2
Dactylis glomerata L.	.	.	.	.	.	+	+	2
Narcissus tazetta L.	.	.	+	.	.	.	.	1
Charybdis maritima (L.) Speta	.	.	+	.	.	.	.	1

Table 8. Continuation.

Relevé (n°)	1	2	3	4	5	6	7	
Altitude (m)	47	165	170	180	250	330	330	
Slope (°)	88	85	90	90	90	85	90	
Aspect	NW	N	NW	NW	NW	W	W	
Area (m²)	20	40	30	40	20	30	20	
Total cover (%)	60	60	50	55	55	65	60	
Herbaceous cover (%)	25	25	25	25	25	25	25	
Average height (cm)	24	21	20	20	29	28	23	Presence
Jacobaea delphiniifolia (Vahl) Pelser et Veldkamp	.	.	.	+	.	.	.	1
Theligonum cynocrambe L.	.	.	.	.	+	.	.	1
Veronica persica Poir.	.	.	.	.	+	.	.	1
Valantia muralis L.	.	.	.	.	+	.	.	1
Smyrnium olusatrum L.	.	.	.	.	+	.	.	1
Lathyrus clymenum L.	.	.	.	.	.	1	.	1
Avena barbata Pott ex Link	.	.	.	.	.	1	.	1
Convolvulus elegantissimus Mill.	.	.	.	.	.	1	.	1
Reseda alba L.	.	.	.	.	.	+	.	1
Ferula communis L.	.	.	.	.	.	+	.	1
Carlina sicula Ten.	.	.	.	.	.	+	.	1

Table 9. Groupment with *Stipellula capensis*.

Relevé (n°)	1	2	3	4	
Altitude (m)	150	180	300	350	
Slope (°)	1	5	8	10	
Aspect	S	S	SE	SE	
Area (m²)	1	1	1	1	
Total cover (%)	75	85	85	90	
Average height (cm)	8	8	8	10	
Species per relevé	21	20	18	23	Presence
Dominant species					
Stipellula capensis (Thunb.) Röser et H.R.Hamasha	4	4	3	5	4
Char. of the alliance					
Trachynia distachya (L.) Link	2	2	2	1	4
Euphorbia exigua L.	+	+	1	+	4
Trisetaria aurea (Ten.) Pignatti	+	2	.	+	3
Sagina apetala Ard.	.	.	+	1	2
Char. of the order and class					
Anisantha fasciculata (C.Presl) Nevski	2	1	2	2	4
Silene colorata Poir.	2	+	1	1	4
Trifolium campestre Schreb.	1	1	+	1	4
Trifolium scabrum L.	1	+	2	2	4
Catapodium hemipoa (Delile ex Spreng.) M.Laínz	2	1	+	1	4
Plantago afra L.	+	+	+	+	4
Hypochaeris achyrophorus L.	+	+	2	+	4
Arenaria leptoclados (Rchb.) Guss.	+	+	.	1	3
Bellis annua L.	+	.	+	+	3
Crupina crupinastrum (Moris) Vis.	.	.	+	+	2
Other species					
Lotus ornithopodioides L.	1	+	1	2	4
Geranium molle L.	1	+	1	+	4
Lagurus ovatus L. subsp. *ovatus*	+	1	.	1	3
Hyoseris radiata L.	+	.	1	1	3
Misopates orontium (L.) Raf.	.	+	1	1	3
Polypodium cambricum L.	1	+	.	.	2
Pennisetum setaceum (Forssk.) Chiov.	+	1	.	.	2
Lotus edulis L.	+	+	.	.	2
Trifolium suffocatum L.	+	.	+	+	2
Asphodelus ramosus L. subsp. *ramosus*	.	1	.	.	1
Carduus pycnocephalus L.	.	.	.	+	1
Umbilicus horizontalis (Guss.) DC.	.	.	.	+	1

Synonym: *Penniseto setacei-Hyparrhenietum hirtae* var. with *Oryzopsis miliacea* (L.) Asch. & Schweinf (in Gianguzzi et al. 1996).

Holotypus: Rel. 1, Table 21, in Gianguzzi et al. (1996, p. 104).

Diagnostic species: *Pennisetum setaceum* (dom.), *Oloptum miliaceum* (= *Oryzopsis miliacea*), *Lobularia maritima*, *Foeniculum vulgare* subsp. *piperitum*, *Sixalis atropurpurea* subsp. *maritima*.

Floristic-syntaxonomical notes: *Pennisetum setaceum*, native of the Middle East and the Arabian Peninsula, has now become thermo-cosmopolite (EPPO 2020) and an invasive alien species that is widespread in the Mediterranean area (D'Amico and Gianguzzi 2006; Pasta et al. 2010). In Sicily, the first record of *Pennisetum setaceum* referred precisely to Monte Pellegrino (Pignatti-Wikus 1963), followed by numerous others that highlighted a constant increase in its distribution across the region (Gianguzzi et al. 1996; D'Amico and Gianguzzi 2006). On the carbonate outcrops of the study area, nowadays it forms large and stabilized grasslands (Fig. 4E) related to the *Penniseto setacei-Hyparrhenietum hirtae* association (Gianguzzi et al. 1996) – of the *Hyparrhenion hirtae* alliance, order *Cymbopogono-Brachypodietalia ramosi*, class *Lygeo-Stipetea* that belongs to the oleaster series (Gianguzzi and Bazan 2019, 2020; Gianguzzi et al. 2020). Over time, it has replaced the vegetation with *Hyparrhenia hirta*, mostly in the thermomediterranean bioclimatic belt (Gianguzzi et al. 1996). In fact, *Pennisetum setaceum* is a strongly competitive species and creates a linear aspect of vegetation along the road margins, previously ascribed to a variant with *Oloptum miliaceum* (sub *Oryzopsis miliacea*; Gianguzzi et al. 1996) of the above-mentioned association. However, this second case consists of a nitrophilous-ruderal coenosis ascribable to the *Bromo-Oryzopsion miliaceae* alliance. As highlighted by Mucina et al. (2016), "... the position of this alliance is contentious. Rivas-Martínez et al. (1999) placed this alliance in the *Agropyretalia repentis* and only three years later Rivas-Martínez (2002) re-classified this unit within the *Carthametalia lanati*. Biondi et al. (2001) gave preference to the *Brachypodio ramosi-Dactylidetalia*. In any case, these conflicting opinions have been obviously motivated by the transitional character of the unit that straddles the border between pseudosteppes and ruderal grass-rich vegetation". On this basis, the description of the new syntaxon in question is deemed appropriate (art. 24b, code of phytosociological nomenclature).

Description: It is a hemicryptophytic, thermo-xerophilous and paucispecific formation, whose physiognomy is dominated by *Pennisetum setaceum* which forms a continuous vegetation belt located along the road margins in the more xeric and sunny parts (Figs 3D, 4E). Compared to *Penniseto setacei-Hyparrhenietum hirtae* – related to rocky limestone slopes – the phytocoenosis in question is different in its poorer floristic composition and the frequency of the above-mentioned ruderal species that are indicated among the typical characteristics (Gianguzzi et al. 1996).

Syndynamism: The association belongs to the more xeric geosigmetum of the road system. In the absence of maintenance works, it tends to colonize the edges of walls that act as parapets, where it is located both inside and outside the road surface, and sometimes also on top. The association is in catenal contact with the following coenoses: a) *Trachynia distachya* groupment (therophytic grassland located in the soil accumulations among the clumps); b) *Capparidetum rupestris* (chasmo-nitrophilous vegetation of the upper parts of sunny and sheltered walls); c) *Rhamno alaterni-Euphorbietum dendroidis* Géhu & Biondi 1997 *artemisietosum arborescentis* subass. nov. (guardwalls of sunny and sheltered parts of the road system).

Synchorology: The phytocoenosis is widespread in the study area, especially along the most xeric parts of the southern and western slopes of the promontory. It is booming in Sicily, mostly along the roads and railways of the coastal belt and, in some cases, in the interior (Gianguzzi et al. 1996, D'Amico and Gianguzzi 2006). This is due to the peculiarity of the seeds (high quantity and high germinability), the anemophilous dissemination (spread over long distances), the biological characteristics of the plant (thick clumps resistant to fires that take space and light from other herbaceous plants) and, in addition – probably – climatic changes.

Cl.: *QUERCETEA ILICIS* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952
Thermo-mesomediterranean pine and oak forests and associated Mediterranean maquis.

Ord.: *PISTACIO LENTISCI-RHAMNETALIA ALATERNI* Rivas-Martínez 1975
Thermo-mesomediterranean low-growth matorral, maquis, and garrigue of the Mediterranean Basin.

All.: *OLEO SYLVESTRIS-CERATONION SILIQUAE* Br.-Bl. ex Guinochet et Drouineau 1944
Thermomediterranean calcicolous maquis of the Liguro-Tyrrhenian seaboards.

11) *RHAMNO ALATERNI-EUPHORBIETUM DENDROIDIS* Géhu & Biondi 1997 *ARTEMISIETOSUM ARBORESCENTIS* subass. nov.

Phytosociological data: Table 10.

Holotypus: Rel. 5, Table 10.

Diagnostic species: *Euphorbia dendroides* (dom.), *Artemisia arborescens*, *Pennisetum setaceum*.

Syntaxonomic notes: The scrub vegetation with Euphorbia dendroides of Sicily is referred to the association *Rhamno alaterni-Euphorbietum dendroidis* Géhu & Biondi 1997 (= *Oleo-Lentiscetum euphorbietosum Molinier* 1954; *Oleo-Euphorbietum dendroidis* Trinajstic 1974; *Oleo-Euphorbietum dendroidis* Trinajstic 1975), divided into the following subassociations, to be considered as geographic vicariants: a) subass. *typicum*; b) subass. *phlomidetosum fruticosae* (Brullo & Marcenò 1985) Gianguzzi et al. 2016 (with *Phlomis fruticosa* L.), on gypsic substrates of the hinterland of Sicily; c) *euphorbietosum bivonae* (Gianguzzi, Ilardi & Raimondo 1996) Gianguzzi et al. 2016 (with *Euphorbia bivonae*), on limestone-dolomitic rocks of Palermo area, Trapani area and near Sciacca; d) *rhamnetosum*

Table 10. *Rhamno alaterni-Euphorbietum dendroidis* Géhu & Biondi 1997 subass. *artemisietosum arborescentis* subass. nov.

Relevé (n°)	1	2	3	4	5*	6	
Altitude (m)	300	310	320	350	350	380	
Slope (°)	5	5	5	5	5	5	
Aspect	SW	W	W	SW	SW	SW	
Area (m²)	40	60	60	50	50	50	
Total cover (%)	100	100	100	90	80	90	
Average height (cm)	40	40	50	50	50	50	
Species per relevé	9	11	10	12	9	11	Presence
Characteristic and differential species of the association and subass.							
Euphorbia dendroides L.	3	3	3	2	3	2	6
Artemisia arborescens L.	3	3	3	4	3	3	6
Pennisetum setaceum (Forssk.) Chiov.	3	3	3	3	2	3	6
Char. of the alliance, order and class							
Rhamnus alaternus L. subsp. *alaternus*	1	2	2	+	2	1	6
Pistacia terebinthus L.	1	2	1	+	.	1	5
Asparagus albus L.	2	1	1	.	1	.	4
Euphorbia bivonae Steud. subsp. bivonae	1	.	.	+	.	.	2
Olea europaea L. var. *sylvestris* (Mill.) Lehr.	.	1	.	+	.	+	3
Asparagus acutifolius L.	.	.	.	.	+	+	2
Other species							
Bituminaria bituminosa (L.) C.H.Stirt.	3	2	2	+	.	.	4
Phagnalon saxatile (L.) Cass.	.	.	1	1	1	1	4
Carlina sicula Ten.	.	1	.	1	+	.	3
Clinopodium nepeta (L.) Kuntze	+	.	.	1	1	1	4
Lomelosia cretica (L.) Greuter et Burdet	.	.	+	.	.	+	2
Reseda alba L.	.	.	.	1	.	1	2
Spartium junceum L.	.	1	.	.	.	.	1
Ailanthus altissima (Mill.) Swingle	.	1	.	.	.	.	1
Silene fruticosa L.	.	.	2	.	.	.	1

oleoidis (Brullo & Marcenò 1985) Gianguzzi et al. 2016 [with *Rhamnus lycioides* L. subsp. *oleoides* (L.) Jahand and Maire], on calcareous, marly and calcarenitic substrates of Trapani and Agrigento are and Egadi Islands (Gianguzzi et al. 2006); e) *celtidetosum aetnensis* (Brullo & Marcenò 1985) Gianguzzi et al. 2016 [*Celtis tournefortii* Lam. subsp. *aetnensis* (Tornab.) Raimondo & Schicchi], on calcareous debris cones of the Sicani Mountains (Gianguzzi et al. 2014a, 2014b). A further xero-nitrophilic vicariant was detected in the study area and diversified by the frequency of *Artemisia arborescens*, proposed as a new subassociation.

Description: Thermo-xerophilous, heliophilous, and nitrophilous, paucispecific maquis formations, clearly dominated by *Euphorbia dendroides*, associated with *Artemisia arborescens* and *Pennisetum setaceum*, with high cover values. The phytocoenosis is typical of warm, sunny, and xeric slopes on carbonate substrata and tends generally to colonize anthropogenic habitats. In particular, it is spread on old walls and ruins.

Syndynamism: In the road system in question, the phytocoenosis takes part in the more xeric geosigmetum, related to the road margins of the southern and western slopes of the promontory (Fig. 4F). It forms nitrophilous-xerophilous maquis vegetation located on the upper parts of guardwalls, sometimes covering them. The association is catenal with the following: a) *Olopto miliacei-Pennisetetum setacei* ass. nov. (road margin vegetation of *Pennisetum setaceum*); b) *Antirrhinetum siculi* (on not very high walls); c) *Capparidetum rupestris* (upper parts of sunny and sheltered walls).

Synchorology: The phytocoenosis was mainly detected along the more xeric parts of the road system on the southern and western sides of the promontory.

12) *TEUCRIO FLAVI-RHOETUM CORIARIAE* Gianguzzi ass. nov.

Phytosociological data: Table 11.

Synonym: Groupment with *Rhus coriaria* (in Gianguzzi et al. 1996); *Clematido cirrhosae-Rubetum ulmifolii* subass. *rhoetosum coriariae* Gianguzzi & La Mantia 2008 (in Gianguzzi and La Mantia 2008).

Holotypus: Rel. 2, Table 11.

Diagnostic species: *Rhus coriaria* (dom.), T*eucrium flavum* subsp. *flavum*, *Bituminaria bituminosa*.

Floristic-syntaxonomical notes: *Rhus coriaria* is a species with a southern range (Pignatti 1982; Pignatti et al. 2017) that is widespread from the Canary Islands to the Middle East (Davis 1967; Tutin et al. 1968; Kurucu et al. 1993; Bloshenko and Letchamo 1995). It is quite common in Italy, as well as in Sicily, as a residue of ancient

Table 11. *Teucrio flavi-Rhoetum coriariae* Gianguzzi ass. nov.

Relevé (n°)	1	2*	3	4	5	6	7	8	9	10	11	12	Presence
Altitude (m)	145	140	150	120	180	100	8	8	150	90	95	90	
Slope (°)	5	5	25	30	25	35	30	30	15	20	25	30	
Aspect	N	N	NE	NE	NE	N	N	N	N	N	N	N	
Area (m²)	100	100	50	100	50	100	80	80	100	80	80	50	
Total cover (%)	100	100	70	70	80	95	80	70	90	95	90	85	
Shrubby cover (%)	70	75	70	70	75	70	70	50	85	90	85	80	
Herbaceous cover (%)	35	30	30	25	30	35	50	60	70	65	70	50	
Average height (cm)	3	2.8	1.5	1.8	1.6	1.5	1.2	1.3	2.8	2.2	2.0	2.2	
Species per relevé	28	25	19	11	12	19	14	15	23	25	19	25	
Characteristic and differential species of the association													
Rhus coriaria L.	5	5	2	4	3	2	2	2	4	3	4	3	12
Teucrium flavum L. subsp. *flavum*	2	+	3	+	1	2	1	1	+	+	.	+	11
Bituminaria bituminosa (L.) C.H.Stirt.	1	+	1	+	.	2	.	+	+	+	+	+	10
Char. of the alliance *Oleo-Ceratonion*													
Euphorbia dendroides L.	+	1	.	+	+	.	1	+	.	.	.	2	7
Olea europaea L. var. *sylvestris* (Mill.) Lehr.	1	+	.	.	.	+	.	+	.	.	.	.	4
Teucrium fruticans L.	+	.	.	.	.	.	.	.	.	.	.	.	1
Char. of the order *Pistacio lentisci-Rhamnetalia alaterni* and class *Quercetea ilicis*													
Rubia peregrina L.	3	2	+	+	.	1	+	+	1	1	1	+	11
Asparagus acutifolius L.	1	1	+	.	.	.	+	.	1	1	1	+	8
Rhamnus alaternus L. subsp. *alaternus*	1	1	.	1	+	1	.	.	1	+	.	+	8
Ampelodesmos mauritanicus (Poir.) T.Durand et Schinz	3	1	+	.	1	1	.	.	1	.	.	1	7
Clematis cirrhosa L.	.	+	.	.	+	.	.	+	+	.	+	.	5
Allium subhirsutum L.	2	1	.	.	.	.	.	.	+	+	+	+	6
Hedera helix L.	+	.	+	.	.	+	.	1	1	.	+	.	6
Arisarum vulgare O.Targ.Tozz.	1	1	.	.	.	.	+	.	1	1	.	+	6
Fraxinus ornus L.	.	.	.	.	+	+	.	.	+	1	1	+	6
Pistacia terebinthus L.	1	+	.	.	.	.	.	.	+	1	.	+	5
Smilax aspera L.	2	1	+	.	.	+	.	.	.	.	.	+	5
Ruta chalepensis L.	+	.	+	.	.	.	.	.	+	+	.	.	4
Euphorbia characias L.	.	1	.	.	.	.	+	1	.	+	.	.	4
Rosa sempervirens L.	.	.	.	.	.	.	+	1	.	.	1	2	4
Prasium majus L.	+	.	.	.	.	+	.	+	.	.	.	.	3
Phillyrea latifolia L.	1	.	.	+	.	+	.	.	.	.	.	.	3
Quercus ilex L.	.	.	.	+	1	1	.	.	.	.	.	.	3
Ruscus aculeatus L.	.	+	+	.	.	.	.	.	.	.	.	.	2
Lonicera implexa Aiton	.	.	.	.	.	.	1	1	.	.	.	.	2
Pistacia lentiscus L.	2	+	+	.	.	.	.	.	.	.	.	.	3
Anagyris foetida L.	1	.	.	.	.	1	.	.	.	.	.	.	2
Osyris alba L.	.	+	+	.	.	.	.	.	.	.	.	.	2
Emerus major Mill.	.	1	.	.	.	.	.	.	.	.	.	.	1
Transgr. of the class *Crataego-Prunetea*													
Rubus ulmifolius Schott	2	1	1	+	1	1	2	2	1	1	1	+	12
Crataegus monogyna Jacq.	.	.	.	.	.	.	1	.	1	2	1	2	5
Rosa canina L.	.	.	1	.	.	2	.	.	.	.	.	.	2
Prunus spinosa L.	.	.	+	.	.	.	.	.	.	.	.	.	1
Other species													
Vicia villosa subsp. varia (Host) Corb.	2	1	.	.	+	.	+	+	1	1	1	+	9
Oxalis pes caprae L.	1	1	.	.	.	.	2	2	2	3	2	1	8
Acanthus mollis L. subsp. *mollis*	2	2	+	+	.	1	.	.	.	.	.	+	6
Brachypodium retusum (Pers.) P.Beauv.	1	.	.	.	.	.	.	.	1	1	1	+	5
Clinopodium nepeta (L.) Kuntze	+	.	.	.	.	+	.	.	.	+	1	1	5
Ferula communis L.	.	.	+	+	.	.	.	.	+	+	+	.	5
Carlina sicula Ten.	.	.	.	.	.	.	.	.	+	+	+	+	4
Scrophularia canina L.	.	+	+	.	+	.	.	.	.	.	.	.	3
Galium cinereum All.	.	1	.	.	.	.	1	.	.	.	+	.	3

Table 11. Continuation.

Relevé (n°)	1	2*	3	4	5	6	7	8	9	10	11	12	
Altitude (m)	145	140	150	120	180	100	8	8	150	90	95	90	
Slope (°)	5	5	25	30	25	35	30	30	15	20	25	30	
Aspect	N	N	NE	NE	NE	N	N	N	N	N	N	N	
Area (m²)	100	100	50	100	50	100	80	80	100	80	80	50	
Total cover (%)	100	100	70	70	80	95	80	70	90	95	90	85	
Shrubby cover (%)	70	75	70	70	75	70	70	50	85	90	85	80	
Herbaceous cover (%)	35	30	30	25	30	35	50	60	70	65	70	50	
Average height (cm)	3	2.8	1.5	1.8	1.6	1.5	1.2	1.3	2.8	2.2	2.0	2.2	
Species per relevé	28	25	19	11	12	19	14	15	23	25	19	25	Presence
Seseli bocconei Guss.	.	.	+	.	.	.	.	.	.	+	.	.	2
Phagnalon saxatile (L.) Cass.	.	.	.	.	.	+	.	.	.	.	+	.	2
Ranunculus millefoliatus Vahl	.	.	.	.	.	.	.	.	1	+	.	.	2
Daucus carota L.	.	.	.	.	.	.	.	.	+	+	.	.	2
Briza maxima L.	.	.	.	.	.	.	.	.	.	+	.	+	2
Charybdis maritima (L.) Speta	.	.	.	.	.	.	.	.	.	+	.	+	2
Smyrnium olusatrum L.	1	.	.	.	.	.	.	.	.	.	.	.	1
Oloptum miliaceum (L.) R.ser et H.R.Hamasha	1	.	.	.	.	.	.	.	.	.	.	.	1
Asphodelus ramosus L. subsp. *ramosus*	.	.	.	.	+	.	.	.	.	.	.	.	1
Dactylis glomerata L.	.	.	.	.	.	.	.	.	.	.	.	+	1

crops for the extraction of tannins. In the interior of Italy, it is widespread in the thermo-mesomediterranean belt where it forms frutescent formations, more or less dense, tendentially monospecific, related to arid slopes, screes, hedges, and abandoned structures (Gianguzzi and La Mantia 2008). From a phytosociological point of view, it is little studied and not well known. Some shrubby aspects, spread across the coastal slopes of Palermo and Trapani areas, have been attributed to the order *Prunetalia spinosae* Tx. 1952 (Gianguzzi et al. 1996; Gianguzzi and La Mantia 2008). A specific association (*Cercido siliquastri-Rhoetum coriariae* Biondi, Allegrezza & Guitian 1988) was described for the central Apennines (Biondi et al. 1988) and ascribed to the same order of the class *Crataego-Prunetea* Tx. 1962 (*Cytision sessilifolii* Biondi 1988). The association in question – according to other authors (Varol et al. 2006; Karaer et al. 2010; Donmez et al. 2015) who have recognized the structural role of *Rhus coriaria* in the xeric shrubby vegetation of Anatolian Peninsula – has been linked to the order *Pistacio-Rhamnetalia alaterni* of the class *Quercetea ilicis*.

Description: It is a shrubby, paucispecific, xerophilous, heliophilous formation, sometimes shady, dominated by *Rhus coriaria*, which is associated with other elements of the *Oleo-Ceratonion* alliance (*Euphorbia dendroides*, *Olea europaea* var. *sylvestris*, and *Teucrium fruticans*) and other sporadic species of the order *Pistacio-Rhamnetalia alaterni*. On this basis, it is here proposed as a new association belonging to these syntaxa. The coenosis is related to rocky slopes with poor soil, screes, and outcrops of carbonate nature (limestone, dolomite, marl, etc.). In the study area, it extends to the road margins and road cut slopes (Fig. 3E).

Syndynamism: The phytocoenosis covers the detritic slopes of the reliefs of carbonate nature. It is a secondary aspect of the holm oak series of *Rhamno alaterni-Querco ilicis pistacio terebinthi* sigmetosum (Brullo and Marcenò 1985; Gianguzzi et al. 1996; Brullo et al. 2008).

Along the road system of Monte Pellegrino, it belongs to the shady-mesic geosigmetum related to the slopes above the roads. Here, it comes in catenal contact with the following coenoses: a) *Helictotricho convoluti-Ampelodesmetum mauritanici* Minissale 1994 (*Ampelodesmos mauritanicus* grassland); b) *Rhamno alaterni-Quercetum ilicis* Brullo and Marcenò 1985 subass. *pistacietosum terebinthi* Gianguzzi et al. 1996 (chasmo-nitrophilous vegetation of the upper parts of walls in sunny locations, sheltered from cold winds).

Synchorology: This vegetation is frequent on the northern and western sides of Monte Pellegrino, in the Allaura area (Gianguzzi et al. 1996). Other similar aspects are widespread along the northern slopes of the mountains of Palermo area, up to Monte Cofano in the province of Trapani (Gianguzzi and La Mantia 2008).

13) Groupment with *RHAMNUS ALATERNUS* and *PISTACIA TEREBINTHUS*

Phytosociological data: Table 12.

Diagnostic species: *Rhamnus alaternus* (dom.), *Pistacia terebinthus*.

Description: It is a maquis or scrub formation dominated by *Rhamnus alaternus* and *Pistacia terebinthus*, associated with other species of the order *Pistacio-Rhamnetalia alaterni*. This vegetation is linked to the upper parts of old walls (5-10 m high) located on the cool and shady slopes of Contrada Allaura, whose toponym refers to the presence of *Laurus nobilis*, a species quite widespread in Sicily (Marino et al. 2014). Thanks to the lack of maintenance work, it tends to colonize the downhill-side of the roads. It creates a border 2-3 meters high, which in some cases overhangs the same walls that act as guardwalls. In fact, the roots of woody plants penetrate through the base of the walls into the fill slopes and road bed (Fig. 3F).

Syndynamism: It belongs to the shady-mesic geosigmetum of the road system linked to the northern face of Monte Pellegrino. It is in catenal contact with the following coenoses: a) *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov. (on lower shady walls); b) *Centranthetum rubri* (on stretches of cool and sheltered walls); c) *Diantho siculae-Helichrysetum panormitani* ass. nov. (on the upper parts of the highest walls).

Synchorology: The vegetation was identified on the northern slopes of Monte Pellegrino, where it forms vegetation strips linked to the upper parts of old retaining walls. Although the phytocoenosis is not very abundant in the area, it has an important documentary value.

Overall considerations on the results

The resulting dataset is composed of 185 taxa divided into 95 samples (relevés). The mean value of the floristic richness is 30 taxa for the retaining wall communities. The most species-rich of the wall communities are the *Diantho rupicolae-Helichrysetum panormitani* (58 taxa), *Crepido bursifoliae-Parietarietum judaicae* (38 taxa), and *Helichryso panormitanae-Hypochaeridetum laevigatae* (36 taxa). These are followed by *Capparidetum rupestris*, *Antirrhinetum siculi*, *Athamanto siculae-Parietarietum judaicae*, and *Centranthetum rubri*, with 25, 19, 16, and 15 taxa, respectively.

The *Stipellula capensis* guardwall groupment includes 28 taxa. In the road margins, the richest communities are the *Rhamno alaterni-Euphorbietum dendroidis* (52 taxa) and *Olopto miliacei-Pennisetetum setacei* (49 taxa), while the *Rhamno alaterni-Euphorbietum dendroidis* and the groupment with *Rhamnus alaternus* and *Pistacia terebinthus* have 22 and 18 taxa, respectively. The overall mean value for the road margin communities is 35 taxa. The *Scabioso creticae-Centaureetum ucriae* of the road cut slopes is the phytocoenosis with the highest species richness (61 taxa), comparable only to *Diantho rupicolae-Helichrysetum panormitani*.

Species nestedness (the average co-occurrence of species, Table 13) is 8.3 among all the communities of the road system, 8.6 among the retaining wall species, and 10 among the road margin species.

The "Jaccard similarity Index" (Table 14) shows a clear differentiation among phytocoenoses (mean value = 0.15). The mean index values of the vegetation is 0.23 for wall vegetation and 0.19 for road margin vegetation. High values of nestedness (45) and Jaccard's Index (0.61) are observed for *Diantho rupicolae-Helichrysetum panormitani* and *Scabioso creticae-Centauretum ucriae*.

The results obtained from detrended correspondence analysis show a clear distribution of communities. The ordination plot (Fig. 5) shows 95 plots grouped in 13 clusters which are quite distinct from floristic and ecological points of view. The compositional turn-over (the measure of beta diversity; Whittaker 1960) across relevés is 6.51. The wall vegetation plots (phytocoenoses 1-7) are spread over the right part of the ordination diagram. The

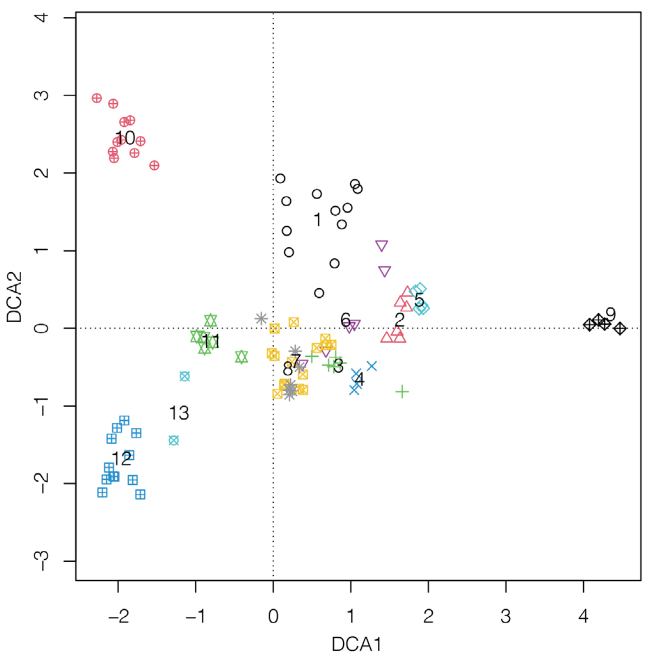

Figure 5. DCA ordination of the community of Monte Pellegrino road system. Legend: 1. *Crepido-Parietarietum*; 2. *Athamanto-Parietarietum*; 3. *Helichryso-Hypochaeridetum*; 4. *Centranthetum*; 5. *Antirrhinetum*; 6. *Capparidetum*; 7. *Diantho Helichrysetum*; 8. *Scabioso-Centauretum*; 9. Gr. *Stipellula*; 10. *Olopto-Pennisetetum* 11. *Rhamno-Euphorbietum*; 12. *Teucrio-Rhoetum*; 13. Gr. *Rhamnus* and *Pistacia*.

Table 12. Groupment with *Rhamnus alaternus* and *Pistacia terebinthus*.

Relevé (n°)	1	2	
Altitude (m)	80	120	
Slope (°)	90	90	
Aspect	N	N	
Area (m^2)	40	30	
Total cover (%)	100	100	
Average height (cm)	40	40	
Species per relevé	13	17	Presence
Guide species			
Rhamnus alaternus L. subsp. *alaternus*	5	5	2
Pistacia terebinthus L.	3	3	2
Char. of the alliance, order and class			
Euphorbia dendroides L.	3	2	2
Asparagus acutifolius L.	2	1	2
Teucrium flavum L. subsp. *flavum*	+	+	2
Artemisia arborescens L.	1	.	1
Ampelodesmos mauritanicus (Poir.) T.Durand et Schinz	.	1	1
Allium subhirsutum L.	.	1	1
Rubia peregrina L.	.	1	1
Smilax aspera L.	.	1	1
Fraxinus ornus L.	.	1	1
Emerus major Mill.	.	1	1
Other species			
Acanthus mollis L. subsp. *mollis*	2	2	2
Phagnalon saxatile (L.) Cass.	+	1	2
Eucalyptus camaldulensis Dehnh.	2	1	2
Pennisetum setaceum (Forssk.) Chiov.	3	.	1
Bituminaria bituminosa (L.) C.H.Stirt.	1	.	1
Carlina sicula Ten.	+	.	1
Reseda alba L.	+	.	1
Galium cinereum All.	.	2	1
Oloptum miliaceum (L.) Röser et H.R.Hamasha	.	1	1
Centranthus ruber (L.) DC.	.	1	1

cluster *Diantho rupicolae-Helichrysetum panormitani* (7) overlaps with the cluster of *Scabioso creticae-Centauretum ucriae* (8) of the road cut slopes. The road margin vegetation (from 10 to 13) is placed on the left part of the diagram, while the guardwall vegetation is on the opposite extreme (9). The distribution of communities in the ordination diagram shows an ecological gradient in term of environmental nitrophilia along the second axis.

From a structural point of view, the life form analysis (Table 15) shows the dominance of Hemicryptophytes in the communities linked to the shaded parts of the walls (*Crepido-Parietarietum*, *Athamanto-Parietarietum*, *Helichryso-Hypochaeridetum*) and the vegetation of the road margins (*Olopto-Pennisetetum* and groupment with *Rhamnus* and *Pistacia*). Chamaephytes are dominant in the communities on exposed parts of the walls (*Centranthetum*, *Antirrhinetum* and *Diantho-Helichrysetum*) and the vegetation of road cut slopes (*Scabioso-Centauretum*). Nanophanerophytes are dominant in *Capparidetum* and *Teucrio-Rhoetum*, while phanerophytes are dominant in *Rhamno-Euphorbietum*. The guardwall groupment with *Stipellula* is physiognomized by therophytes.

Discussion

The phytocoenoses detected along the Monte Pellegrino road system are the result of a process of sponteaneous plant colonization on man-made infrastructure, built in a context of particular naturalistic value. These communities have gradually evolved in an almost undisturbed way, as maintenance has been limited to the sporadic removal or cutting of vegetation only at the road margins and the edges of drainage ditches. The masonry works and rock walls delimiting the uphill and downhill sides of the entire road system have been completely unmaintained.

The rock walls created from the excavation of the limestone substrate, have also been subjected to a slow colonization process by chasmophytic species, typical of natural rock faces, which are also very common in the area. Disturbances of these areas have been limited to the placing of metal mesh in a few sections to stabilize the slope. However, this did not preclude the settlement of rupicolous associations, such as *Scabioso creticae-Centauretum ucriae* (shady-mesic slopes) and *Capparidetum rupestris*

Table 13. Shared species ('a' component of the "Jaccard Index") among communities of the road system.

A value	C-Pa	A-Pa	H-Hy	Cen	Ant	Cap	D-He	S-Ce	g-St	O-Pe	R-Eu	T-Rh
A-Pa	9											
H-Hy	10	9										
Cen	6	7	15									
Ant	8	7	8	6								
Cap	8	9	12	8	8							
D-He	11	14	24	11	12	20						
S-Ce	11	9	21	10	10	17	45					
g-St	3	6	4	2	7	3	5	3				
O-Pe	11	2	5	0	5	4	11	10	1			
R-Eu	2	1	5	1	4	4	13	12	1	7		
T-Rh	8	3	9	3	2	5	16	17	1	10	9	
g-Rh	3	2	8	3	3	4	15	12	1	7	10	17

Table 14. "Jaccard similarity Index" among communities of the road system.

Jaccard	C-Pa	A-Pa	H-Hy	Cen	Ant	Cap	D-He	S-Ce	g-St	O-Pe	R-Eu	T-Rh
A-Pa	0.20											
H-Hy	0.16	0.21										
Cen	0.13	0.29	0.43									
Ant	0.16	0.25	0.17	0.21								
Cap	0.15	0.28	0.25	0.25	0.22							
D-He	0.13	0.23	0.35	0.18	0.18	0.32						
S-Ce	0.13	0.13	0.28	0.15	0.14	0.25	0.61					
g-St	0.05	0.16	0.07	0.05	0.18	0.06	0.06	0.04				
O-Pe	0.15	0.03	0.06	0.00	0.08	0.06	0.12	0.10	0.01			
R-Eu	0.04	0.03	0.10	0.03	0.12	0.10	0.21	0.18	0.02	0.12		
T-Rh	0.10	0.05	0.12	0.05	0.03	0.07	0.17	0.18	0.01	0.11	0.15	
g-Rh	0.05	0.06	0.16	0.09	0.08	0.09	0.23	0.17	0.02	0.11	0.33	0.30

Table 15. Life form of the communities of the road system (C-Pa: *Crepido-Parietarietum*; A-Pa: *Athamanto-Parietarietum*; H-Hy: *Helichryso-Hypochaeridetum*; Cen: *Centranthetum*; Ant: *Antirrhinetum*; Cap: *Capparidetum*; D-He: *Diantho-Helichrysetum*; S-Ce: *Scabioso-Centauretum*; 9. F-St: gr. *Stipellula*; O-Pe: *Olopto-Pennisetetum*; R-Eu: *Rhamno-Euphorbietum*; T-Rh: *Teucrio-Rhoetum*; g-Rh: Gr. *Rhamnus* and *Pistacia*).

Flora	C-Pa	A-Pa	H-Hy	Cen	Ant	Cap	D-He	S-Ce	g-St	O-Pe	R-Eu	T-Rh	g-Rh
CH	7.9	6.3	25.7	33.3	10.5	28.0	29.3	29.5	0.0	4.2	16.7	9.6	13.6
G	10.5	18.8	11.4	20.0	5.3	4.0	8.6	11.5	7.4	8.3	0.0	9.6	4.5
H	28.9	31.3	22.9	20.0	15.8	20.0	22.4	24.6	11.1	47.9	22.2	26.9	27.3
NP	2.6	0.0	5.7	6.7	10.5	8.0	13.8	11.5	0.0	2.1	27.8	19.2	22.7
P	2.6	6.3	5.7	0.0	0.0	8.0	6.9	3.3	0.0	2.1	27.8	26.9	13.6
T	47.4	37.5	28.6	20.0	57.9	32.0	19.0	19.7	81.5	35.4	5.6	7.7	18.2
Freq.	**C-Pa**	**A-Pa**	**H-Hy**	**Cen**	**Ant**	**Cap**	**D-He**	**S-Ce**	**g-St**	**O-Pe**	**T-Rh**	**R-Eu**	**g-Rh**
CH	9.6	7.3	27.4	29.2	13.5	31.8	44.4	42.4	0.0	1.9	11.3	9.4	16.7
G	10.5	12.7	13.2	18.8	6.8	4.5	4.1	9.1	2.4	7.8	0.0	9.8	3.3
H	32.5	38.2	24.5	25.0	18.9	21.2	23.7	21.8	6.1	60.2	27.4	23.0	23.3
NP	1.8	0.0	2.8	4.2	4.1	12.1	8.7	11.5	0.0	1.5	32.3	19.6	23.3
P	0.9	3.6	5.7	0.0	0.0	3.0	3.3	1.8	0.0	2.4	25.8	27.7	16.7
T	44.7	38.2	26.4	22.9	56.8	27.3	15.8	13.3	91.5	26.2	3.2	10.6	16.7
Cover	**C-Pa**	**A-Pa**	**H-Hy**	**Cen**	**Ant**	**Cap**	**D-He**	**S-Ce**	**g-St**	**O-Pe**	**T-Rh**	**R-Eu**	**g-Rh**
CH	0.6	1.0	7.5	74.9	75.7	13.6	87.4	86.7	0.0	0.2	1.7	6.9	0.0
G	0.6	1.6	3.6	2.4	2.1	0.7	0.8	2.0	0.3	10.4	0.0	9.7	24.4
H	91.8	88.5	79.7	7.4	5.7	3.6	5.7	5.1	0.7	85.0	34.6	9.7	66.5
NP	0.1	0.0	0.7	0.7	1.2	77.3	2.1	2.8	0.0	0.2	57.8	9.0	0.2
P	0.0	0.4	1.7	0.0	0.0	0.4	0.8	0.5	0.0	0.3	5.7	57.6	0.5
T	6.7	8.4	6.8	14.6	15.3	4.4	3.2	3.0	99.0	3.9	0.2	7.2	8.3

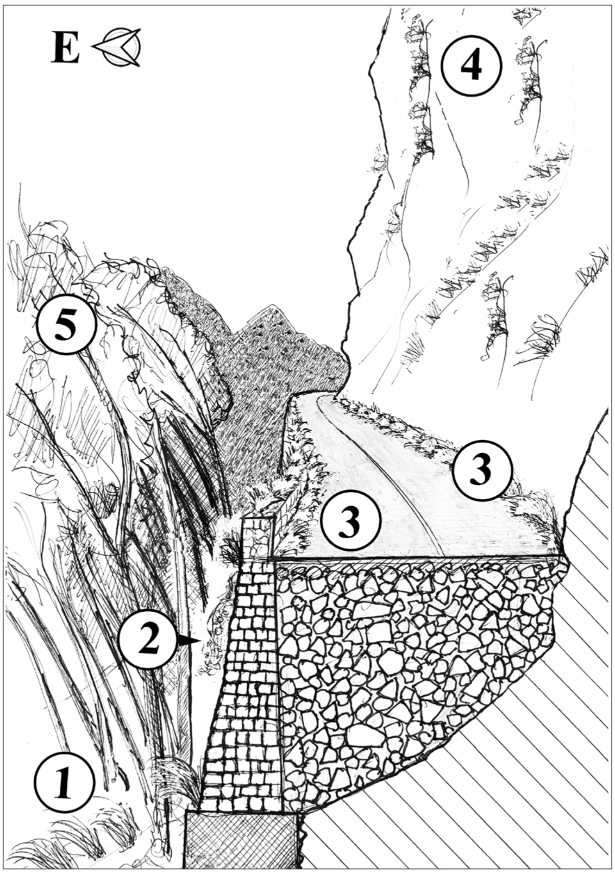

Figure 6. Schematic transect of the xeric geosigmetum of the Monte Pellegrino road system (via Pietro Bonanno, on the slopes of Arenella before the hairpin bend overlooking Palermo, 120 m a.s.l.): 1) grassland vegetation with *Pennisetum setaceum* (*Penniseto setacei-Hyparrhenietum hirtae*); 2) thermo-chasmophytic wall vegetation with *Capparis spinosa* (*Capparidetum rupestris*); 3) road margin hemicryptophytic, nitrophilous vegetation with *Pennisetum setaceum* (*Olopto miliacei-Pennisetetum setacei* ass. nov.); 4) chasmophytic cliff vegetation with *Lomelosia cretica* (*Scabioso-Centauretum ucriae)*; 5) artificial forest plantations with *Eucalyptus camaldulensis* and *Pinus halepensis*.

Overall, depending on the microclimatic diversification of the Monte Pellegrino promontory where the roadway under investigation was built, it is possible to distinguish two different microgeoseries of the road system: respectively a xerophilous and a shady-mesic one.

The xerophilous microgeoseries can be found along the stretches of the southern and western slopes, starting from the foot of the mountain, the so-called "falde di Monte Pellegrino". The most representative features (xeric slopes), both previously noted in this area (Brullo and Marcenò 1979; Gianguzzi et al. 1996).

The syndynamic diversification of the road system is primarily related to the main habitats characterizing the individual stretches of road, such as retaining walls, road embankments and rocky walls, masonry guardwalls and road margins.

Indeed, it can be observed that, under conditions of microtopographic homogeneity in a road section (e.g., along the straightaways), the phytocoenoses tend to maintain their homogeneity. On the contrary, as certain ecological factors vary (slope, exposure of the individual stretch of road, altitude, available shade, nitrophilia, availability or lack of nutrients, etc.), the arrangement of the coenoses tends instead to vary with substitutions or interpenetrations.

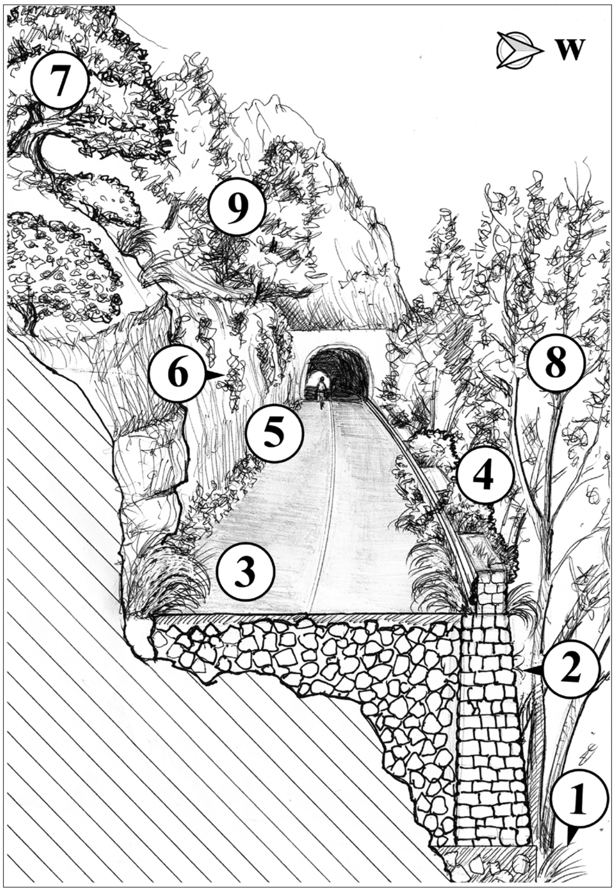

Figure 7. Schematic transect of the xeric geosigmetum of the Monte Pellegrino road system (upper part of via Monte Ercta, near the tunnel on the slopes above the Favorita park of Palermo, 310 m a.s.l.): 1) grassland vegetation with *Pennisetum setaceum* (*Penniseto setacei-Hyparrhenietum hirtae*); 2) chamaephytic wall vegetation dominated by *Antirrhinum siculum* (*Antirrhinetum siculi*); 3) hemichryptophytic nitrophilous vegetation of the road margins with *Pennisetum setaceum* (*Olopto miliacei-Pennisetetum setacei* ass. nov.); 4) nitro-xerophilous vegetation with *Euphorbia dendroides* and *Artemisia arborescens* (*Rhamno-Euphorbietum artemisietosum arborescentis* subass. nov.); 5) chasmo-nitrophilous, sciaphilous vegetation with *Parietaria judaica* (*Crepido bursifoliae-Parietarietum judaicae* ass. nov.); 6) chasmophytic coenosis with *Lomelosia cretica* (*Scabioso-Centauretum ucriae*); 7) vegetation with *Olea europaea* var. *sylvestris* (*Ruto chalepensis-Oleetum sylvestris*); 8) artificial forest plantation with *Eucalyptus camaldulensis*; 9) artificial forest plantation with *Pinus halepensis*.

of this microgeoseries are schematized in Fig. 6 and Fig. 7. The relevant area falls within the range of the xerophilous series of *Ruto chalepensis-Oleo sylvestris* sigmetum (Gianguzzi and Bazan 2019, 2020; Gianguzzi et al. 2020), consisting of an oleaster formation (*Ruto-Oleetum sylvestris*), secondary aspects of *Euphorbia dendroides* maquis (*Rhamno-Euphorbietum dendroidis euphorbietosum bivonae*), *Pennisetum setaceum* grassland (*Penniseto setacei-Hyparrhenietum hirtae*) and therophitic grasslands of the class *Stipo-Trachynietea distachyae* (Fig. 3e).

The shady-mesic microgeoseries of the road system is, instead, found on the northern slope of the promontory; its exemplary characteristics are schematized in Fig. 8 and Fig. 9. It falls within the context of the *Rhamno alaterni-Querco ilicis pistacietosum terebinthi* sigmetosum series

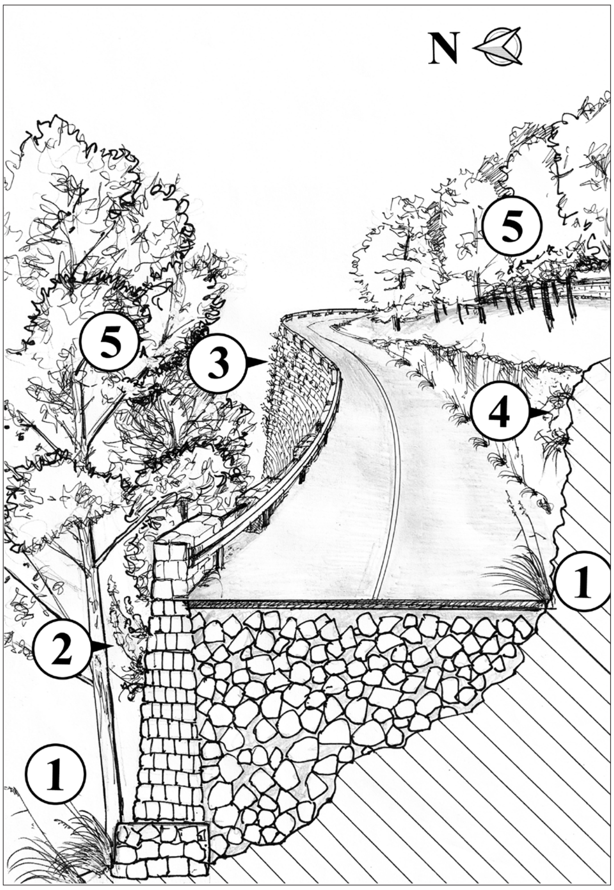

Figure 8. Schematic transect of the shady-mesic geosigmetum of the Monte Pellegrino road system (via Monte Ercta, descending toward Mondello, at the first harpin bend in the slopes above Contrada Allaura, 240 m a.s.l.): 1) grassland with A*mpelodesmos mauritanicus* (*Helictotricho-Ampelodesmetum mauritanici*); 2) chasmo-nitrophilous, heliophilous coenosis of lower and cooler walls with *Centranthus ruber* (*Centranthetum rubri*); 3) chasmophytic, heliophilous vegetation of higher old and cool walls with *Helichrysum panormitanum* subsp. *panormitanum* (*Diantho siculae-Helichrysetum panormitani* ass. nov.); 4) chasmophytic coenosis with *Lomelosia cretica* (*Scabioso-Centauretum ucriae*); 5) artificial forest plantation with *Pinus halepensis*.

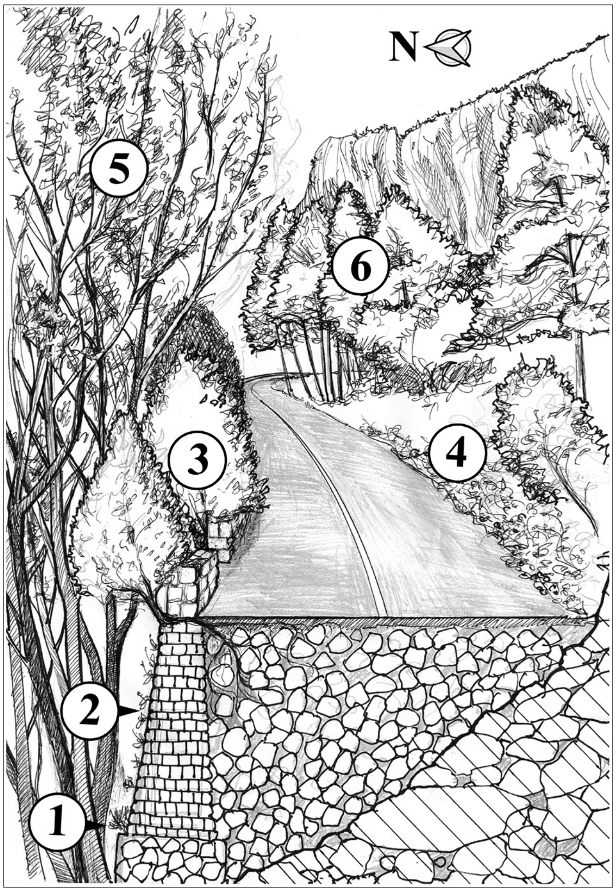

Figure 9. Schematic transect of the shady-mesic geosigmetum of the Monte Pellegrino road system (via Monte Ercta, at the last harpin bend on the slopes above Contrada Allaura, descending toward Mondello, 120 m a.s.l.): 1) chasmo-nitrophilous with Parietaria judaica (*Crepido bursifoliae-Parietarietum judaicae* ass. nov.); 2) cemicryptophytic-camaephytic, sciaphilous vegetation on old walls with *Hypochaeris laevigata* (*Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov.); 3) nitrophilous maquis of old walls (*Rhamnus alaternus* and *Pistacia terebinthus* groupment); 4) secondary maquis of detritic slopes (*Teucrio flavi-Rhoetum coriariae* Gianguzzi ass. nov.); 5) artificial forest plantation with *Eucalyptus camaldulensis*; 6) artificial forest plantation with *Pinus halepensis*.

(Gianguzzi et al. 1996; Brullo et al. 2008), which is made up of holm oak woods (*Rhamno alaterni-Querco ilicis* subass. *pistacietosum terebinthi*), *Rhus coriaria* shrubland (*Teucrio flavi-Rhoetum coriaria* Gianguzzi ass. nov.), *Ampelodesmos mauritanicus* grassland (*Helictotricho-Ampelodesmetum mauritanici*), and therophitic grasslands of the class *Stipo-Trachynietea distachyae*.

Among the new associations described, two of them concern communities dominated by *Parietaria judaica* (*Crepido bursifoliae-Parietarietum* ass. nov. and *Athamanto siculae-Parietarietum* ass. nov.), related to different areas of the masonry structures. Here, in fact, the widespread presence of the aforementioned vital and invasive dominant species tends to impose similar physiognomies on different ecological contexts, making it difficult to concretely identify phytocoenoses. However, those which are settled at the base tend to have a floristic composition rich in synanthropic and ruderal elements of the classes *Stellarietea*, *Lygeo-Stipetea* (*Bromo-Oryzopsion*) and *Polygono-Poetea annuae*, differently from the slightly higher parts of the walls. There, in fact, the *Parietaria* vegetation reveals a total absence of such elements and is, instead, enriched with other, rather rare chasmophytic species of the class *Asplenietea trichomanis* (e.g., *Athamanta sicula*), allowing a clear diversification of the coenoses.

Generally, plant communities growing on these kinds of walls normally form anthropogenic coenoses characterized by nitrophilic and nutrient needy plants as they are subjected to the crumbling of their underlying materials (rocks and mortar) which allow for the fertilization and humidification of the surfaces. The wall plants thus tend to form relatively unstable formations in the long term, also due to anthropic disturbances (cleaning, restoration, reconstruction, etc.) which benefit neophytes and species arriving via anthropochory dissemination (Bartolo and Brullo 1986; Brullo and Guarino 1998, 2002).

Along the old walls of the Monte Pellegrino road system, conversely, the absence of these human disturbances has led, over time, to the establishment of communities that are partly unique, as in the case of *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov. and *Diantho siculae-Helichrysetum panormitani* Gianguzzi ass. nov., both dominated by *Asteraceae* with anemophilous distribution. These are two peculiar, endemic coenoses of this local area.

Among the vegetation aspects of the road margins, *Olopto miliacei-Pennisetetum setacei* Gianguzzi ass. nov. stands out. This is a nitrophilic-ruderal coenosis of the *Bromo-Oryzopsion miliaceae* alliance, dominated by *Pennisetum setaceum*, a rapidly expanding invasive exotic along the coastal roads of Sicily, linked to the more xeric bioclimatic zone. On the road embankments of the northern slope, it is substituted by vegetation dominated by *Ampelodesmos mauritanicus* (*Helictotricho convoluti-Ampelodesmetum mauritanici*), presenting prairie aspects linked to the holm oak series (*Rhamno alaterni-Querco ilicis* sigmetum). The shrubby phytocoenoses linked to the less disturbed road margins are: *Rhamno alaterni-Euphorbietum dendroidis artemisietosum arborescentis* subss. nov., *Teucrio flavi-Rhoetum coriariae* Gianguzzi ass. nov., and a maquis dominated by *Rhamnus alaternus* and *Pistacia terebinthus*, while the chasmophytic associations tied to rupicolous habitat are *Capparidetum rupestris* and *Scabioso creticae-Centauretum ucriae*.

The phytosociological analysis of the various anthropogenic habitats (masonry retaining wall, masonry guardwall, road margins, rock cut slope) has shown that these communities, though autonomous, have floristic relationships and affinities both with the natural phytocoenoses of Monte Pellegrino, external to the road system, and with the phytocoenoses of the other habitats that are part of the road system. The latter, in fact, develop in contact with each other within the habitat sequence.

Among the natural phytocoenoses, there are mainly rupicolous communities, grassland and Mediterranean maquis formations, which are quite extended throughout the promontory. They constitute the source habitats of the main species which, in turn, play an important pioneer role in the gradual colonization process of the artificial micro-habitats characterizing the road system. These are closely related phytocoenoses, which differ according to variations of ecological gradient within the sequence in the respective geosigmeta.

Concluding considerations

The phytosociological study of the vegetation connected to the Monte Pellegrino road system allowed us to differentiate 10 associations, 1 sub-association and 2 groupment, in turn ascribed to 5 different classes of vegetation. These plant communities settled down through a slow colonization process that lasted about a century, distributed across the artificial microhabitats of the route according to the topography and the microclimatic factors of the sites. Recent anthropogenic factors (direct and indirect) are of limited significance, restricted to sporadic cleaning of the road margins and slopes. There was no maintenance of the retaining walls, where chasmophytic vegetation was able to settle and evolve undisturbed. It should also be noted that the disturbance of the wall vegetation by fires was almost nonexistent given their low frequency in the area. On this basis, peculiar and endemic phytocoenoses could also develop, such as *Helichryso panormitanae-Hypochaeridetum laevigatae* ass. nov. and *Diantho siculae-Helichrysetum panormitani* Gianguzzi ass. nov.

The different phytocoenoses detected reflect the high number of microhabitats present in the road system under investigation, which are differentiated according to the slopes and the altitude of this suburban road. Some of these communities have been described as new associations or sub-associations, while other chasmophytic formations (e.g., *Centranthetum rubri* and *Antirrhinetum siculi)* were not reported for this area in a previous contribution on vegetation (Gianguzzi et al. 1996).

The chasmophytic vegetation includes some phytocoenoses whose microtopographic location is closely linked to the different conditions present along the profile of the walls and rock faces. In fact, the species that grow towards the base are normally more numerous than those that are typical of the upper parts of the walls, where survival is more difficult. This is due, above all, to a lack of suitable hollows – which are also poor in soil, moisture, and useful nutrients – in addition to more direct wind exposure and a higher temperature range (daily and annual). This obviously made the initial establishment, as well as the growth and development of plants, more difficult. Additionally, the dispersion of seeds – regardless of the diffusion vector, biotic (animals, insects, etc.) or abiotic (wind, water, etc.) – as well as germination tend to decrease in almost direct proportion to distance from the ground.

In the floristic settlement of the coenoses there are several exotic and alien species (e.g., *Boerhavia repens*, *Pennisetum setaceum*, *Oxalis pes-caprae*, etc.), some of which are even dominant and characteristic of specific plant communities (*Penniseto setacei-Hyparrhenietum hirto-pubescentis*, Gianguzzi et al. 1996 and *Olopto miliacei-Pennisetetum setacei* Gianguzzi ass. nov.). This is in addition to other species and communities which have already been reported for the promontory, such as *Ricinus communis*, *Ailanthus altissima*, *Opuntia stricta*, *O. dillenii*, *Agave americana*, *A. sisalana*, *Nicotiana glauca*, *Arundo donax*, *Vachellia karroo*, *Parkinsonia aculeata*, *Asparagus asparagoides*, etc. (Gianguzzi et al. 1996). In this sense, road networks act as corridors for the diffusion of alien species as evidenced by the presence of these non-native invasive plants.

It can therefore be said that the Monte Pellegrino promontory acts as a refuge site in both floristic and coenological terms, in particular on the more xeric (southern and western) slopes. Some of these elements are even in the process of expansion, having found important ecological spaces, and not only on Monte Pellegrino; this is the case of *Pennisetum setaceum* which, in addition to being invasive to grassland (with the association *Penniseto setacei-Hyparrhenietum hirtae*, which is also increasing on neighboring hills, such as Monte Gallo, Monte Palmeto, Monte Pecoraro, etc.), also tends to expand along the road margins of the most xeric areas of Sicily.

In conclusion, the Monte Pellegrino promontory, despite some current threats, retains floristic and phytocoenotic distinctiveness and good coenological diversity which is partly of anthropogenic nature. On the basis of these considerations, it can be confirmed that suburban and rural road systems created with traditional techniques can sometimes take on important roles as reservoirs of biodiversity.

Syntaxonomic scheme

Phytosociological and statistical analyses of the vegetation allowed us to organize the phytocoenoses listed in the following syntaxonomic scheme.

CYMBALARIO-PARIETARIETEA DIFFUSAE Oberd. 1969
TORTULO-CYMBALARIETALIA Segal 1969
Galio valantiae-Parietarion judaicae Rivas-Mart. ex O. de Bolòs 1967
Crepido bursifoliae-Parietarietum judaicae ass. nov.
Athamanto siculae-Parietarietum judaicae ass. nov.
Helichryso panormitanae-Hypochaeridetum laevigatae ass. nov.
Centranthetum rubri Oberd. 1969
Antirrhinetum siculi Bartolo & Brullo 1986
Artemisio arborescentis-Capparidion spinosae Biondi, Blasi et Galdenzi in Biondi *et al.* 2014
Capparidetum rupestris O. Bolòs & Molinier 1958

ASPLENIETEA TRICHOMANIS (Br.-Bl. in Mei. & Br.-Bl. 1934) Ober. 1977
ASPLENIETALIA GLANDULOSI Br.-Bl. & Meier in Meier & Br.-Bl. 1934
Dianthion rupicolae Brullo & Marcenò 1979
Diantho siculae-Helichrysetum panormitani Gianguzzi ass. nov.
Scabioso creticae-Centauretum ucriae Brullo & Marcenò 1979

STIPO-TRACHYNIETEA DISTACHYAE S. Brullo in S. Brullo *et al.* 2001
BRACHYPODIETALIA DISTACHYAE Rivas-Martínez 1978
Hypochoeridion achyrophori Biondi & Guerra 2008
Groupment with *Stipellula capensis*

ARTEMISIETEA VULGARIS Lohmeyer *et al.* in Tx. Ex von Rochow 1951
ELYTRIGIO REPENTIS-DITTRICHIETALIA VISCOSAE Mucina in Mucina *et al.* 2016
Bromo-Oryzopsion miliaceae O. Bolòs 1970
Olopto miliacei-Pennisetetum setacei Gianguzzi ass. nov.

QUERCETEA ILICIS Br.-Bl. in Br.-Bl., Roussine & Nègre 1952
PISTACIO LENTISCI-RHAMNETALIA ALATERNI Rivas-Martínez 1975
Oleo sylvestris-Ceratonion siliquae Br.-Bl. ex Guinochet & Drouineau 1944
Rhamno alaterni-Euphorbietum dendroidis Géhu & Biondi 1997
artemisietosum arborescentis subass. nov.
Teucrio flavi-Rhoetum coriariae Gianguzzi ass. nov.
Groupment with *Rhamnus alaternus* and *Pistacia terebinthus*

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Appendix - Location and dates of relevés

Table 1 – *Crepido bursifoliae-Parietarietum judaicae:* Rels. 1-4, Palermo (14.5.2016); Rels. 5-7, via Bonanno (foot of M. Pellegrino): base of masonry and rock walls on the sea side (12.6.2016); Rels. 8-9, via Monte Ercta near

the second tunnel, under the rock wall (10.5.2016); Rels. 10-12, Grotta di St. Rosalia square, at the base of a wall (10.6.2016).

Table 2 – *Athamanto siculae-Parietarietum judaicae*: Rels. 1-2, via Bonanno, retaining wall near the Utveggio castle (10.6.2019); Rels. 3-6, Wall in the square in front the St. Rosalia Sanctuary (10.6.2019).

Table 3 – *Helichryso panormitanae-Hypochaeridetum laevigatae*: Rels. 1-3, Walls above the hairpin bend of Contrada Allaura (10.5.2019); Rel. 4, Wall above Cda Allaura (10.5.2019); 5-6, Wall in the slope above Mondello.

Table 4 – *Centranthetum rubri*: Rels. 1-4, Walls above the Contrada Allaura (21.4.2016);

Table 5 – *Antirrhinetum siculi*: Rels. 1-2, Road to the antennas (18.5.2016); 3-4, via M. Ercta (21.5.2017); 5, Road to the antennas (21.5.2017).

Table 6 – *Capparidetum rupestris*: Rels. 1-2, Wall above the Contrada Arenella (18.5.2016); Rels. 3-4, Wall before the last hairpin bend above the Contrada Arenella (18.5.2016); 5-6, Wall of Contrada Arenella (by Gianguzzi et al. 1993).

Table 7 – *Diantho rupicolae-Helichrysetum panormitani*: Ril. Rels. 1-15, Hight walls of via Monte Ercta, between the Contrada Allaura and the Sanctuary (10.6.2016).

Table 8 – *Scabioso creticae-Centauretum ucriae* Brullo et Marcenò 1979 subass. *typicum*: Rel. 1, Mountain-side wall near the first hairpin bend before the Favorita (21.4.2016); Rel. 2, Mountain-side wall at the first hairpin bend above Mondello; Rels. 3-4, Mountain-side wall before the last tunnel (4.5.2016); Rels. 5-7, Mountain-side wall, shortly before the Santuary (4.5.2016).

Table 9 – Groupment with *Stipellula capensis*: Rels. 1-2, Old walls (parapets) along via Bonanno, above the Arenella side (10.5.2018); Rels. 3-4, parapets along the old road to the Sanctuary (10.6.2019)

Table 10 – *Rhamno alaterni-Euphorbietum dendroidis* Géhu & Biondi 1997 subass. *artemisietosum arborescenti*: Rels. 1-2, via Bonanno (12.6.2016); Rels. 3-6, via Monte Ercta (12.6.2016).

Table 11 – *Teucrio flavi-Rhoetum coriariae*: Rels. 1-2, Detritic slopes along the road to Monte Pellegrino at Contrada Allaura near the first tunnel (10.6.2016); Rels. 3-6, clearing of Allaura woodland (25.6.1995; by Gianguzzi et al. 1996, Tab. 7); Rels. 7-8, Monte Cofano Natural Reserve, at Contrada Frassino (15.02.2001; by Gianguzzi and La Mantia, 2008); 9-11: Villagrazia di Carini, under the cliffs of Montagna Longa (15.05.2001; by Gianguzzi and La Mantia, 2008); 12, Monte Pellegrino, in the clearing of Allaura woodland (25.06.1995; by Gianguzzi and La Mantia, 2008).

Table 12 – Groupment with *Rhamnus alaternus* e *Pistacia terebinthus*: Rels. 1-2, via Monte Ercta, along the wall of Contrada Allaura (12.6.2016).

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Intraspecific variability of leaf traits and functional strategy of *Himantoglossum adriaticum* H. Baumann

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Abstract

Trait-based studies have become extremely common in plant ecology. In this work we analysed intraspecific trait variation of *Himantoglossum adriaticum*, a European endemic orchid species of Community interest, to investigate whether different populations growing on managed and abandoned semi-natural dry grasslands show differences in the CSR strategy. In seven populations occurring in Veneto Region (NE Italy), we measured *H. adriaticum* maximum vegetative height, leaf traits (LA, LDMC, SLA) and calculated the CSR strategy. Through CCA we investigated the relationship between plant traits and both plant community attributes (cover and height of herbs and shrubs), and geomorphologic features (aspects and slope). PERMANOVA test was used to investigate if the CSR strategy of *H. adriaticum* varied according to the management regime. Results showed that individuals of *H. adriaticum* develop different strategies when growing in different habitats. Specifically, individuals growing in managed fully sunny dry grasslands reached higher vegetative height (MH), had lower values of SLA and a higher relative contribution of the C parameter than individuals growing in abandoned dry grasslands, which, on the contrary, were shorter, had higher values of SLA (and correspondingly lower values of LDMC) and a higher relative contribution of the R parameter. Further data on reproductive traits (e.g. fruit and seed-set) may corroborate our results. Although the number of individuals addressed in this study is rather low, and our conclusions may not be considered of general validity for the species, our study demonstrated the applicability of the CSR strategy scheme in detecting functional strategies at intraspecific level.

Keywords

CSR plant strategy theory, dry grasslands, *Himantoglossum adriaticum*, intraspecific trait variation, land-use change, plant traits

Introduction

Trait-based studies have become extremely common in plant ecology (Chelli et al. 2019). This conceptual framework implies describing species through their biological characteristics by measuring suites of traits, i.e. features measurable at the individual level, that are assumed to impact plant fitness and survival (Pierce et al. 2017), either directly or indirectly (Violle et al. 2007).

Although species identity provides major information for ecological studies, the traditional taxonomic description becomes less effective when we are to understand plant reactions to environmental changes, e.g. climate or natural/anthropogenic disturbance, and the processes behind them (Westoby et al. 2002; Garnier et al. 2004). As measurable properties of individuals, functional traits allow understanding the interactions between organisms and their environment (both abiotic and biotic) and bring a functional perspective to the study on biodiversity and how it affects processes at higher levels of organization. Indeed, plant traits have been proved to vary with e.g. environmental conditions (Tautenhahn et al. 2008; Garnier and Navas 2012; Ivanova et al. 2019), land-use (Purschke et al. 2013; Duflot et al. 2014), and species distributions (Violle et al. 2014) suggesting that traits reflect the strategies plants use to cope with the environment and directly influence species interactions and the properties of communities and ecosystems (Grime 2006; Albert et al. 2011; Fantinato and Buffa 2019; Fantinato et al. 2019a, 2019b).

Several studies suggest the existence of sets of plant traits that co-vary, thereby allowing the identification of syndromes that affect survival (e.g. Díaz et al. 2004; Cerabolini et al. 2010; Funk et al. 2016); however, there is no consensus yet on any particular ecological scheme (Pierce et al. 2017). One of the first suggested frameworks is the so-called "leaf economic spectrum" (LES), proposed by Wright et al. (2004); it distinguishes species according to their resource uptake dynamics from quick (acquisitive) to slow return on investment of resources (conservative). Another notable and popular strategy scheme is the CSR (competitor, stress tolerator, ruderal) theory by Grime (1974, 1977), recently reviewed by Grime and Pierce (2012). According to this theory, plant species are assigned to three main strategies which represent trait combinations arising under conditions of competition, abiotic limitation to growth or periodic biomass destruction, respectively (Pierce et al. 2017). These primary strategies represent the extremes, and CSR classification reflects the full spectrum of possible intermediate types. The scheme has been so far adopted at different levels of organization, worldwide (e.g. Yildirim et al. 2012; Astuti et al. 2019; Giupponi and Giorgi 2019; Nyakunga et al. 2018), and values on CSR strategy are currently available for several species (Cerabolini et al. 2010; Pierce et al. 2017). In most trait databases, species are described by mean trait values, regardless of environmental or genetic context (Albert et al. 2010), mostly due to the search for general patterns (Albert et al. 2011). However, plants change their traits not only from species to species (interspecific trait variability) but also among populations of the same species (intraspecific trait variability) when growing in different environment. Recent examples (Lecerf and Chauvet 2008; Messier et al. 2010) showed that intraspecific trait variability plays a crucial role, especially at local scale (Albert et al. 2011). Volis et al. (2004) found that plants of wild barley (*Hordeum spontaneum* Koch) from favourable environments were better competitors than those from stressful environments. Similarly, Pierce et al. (2013) classified individual plants of the genus *Poa*, showing within populations trait variation. Intraspecific trait variability thus might help reveal a species' ability to respond to environmental variations and has been proven to have direct effects on e.g. community assembly (Jung et al. 2010) and nutrient cycles (Lecerf and Chauvet 2008).

In light of the above, this study aims at investigating whether populations of the Adriatic Lizard Orchid (*Himantoglossum adriaticum* H. Baumann), growing on managed and abandoned semi-natural dry grasslands show differences in the CSR strategy. The evaluation of intraspecific trait variability might be the key to understanding the interactions between *H. adriaticum* and the extant community and reveal its ability to respond to environmental variations.

Materials and method

Study Area

The study took place on two hilly massifs of the Veneto Region (NE Italy): the Berici Hills (N 45.443.909; E 11.516.229) and the Euganei Hills (N 45.315.955; E 11.702.056), originated from volcanic (basaltic and rhyolitic) bedrock (Macera et al. 2003), and located southward of the Pre-Alps. Average annual rainfall is 800-1000 mm, distributed according to an equinoctial pattern with two maxima in April and September and two minima in December and July. Annual mean temperature is about 13.0-14.0 °C; the highest average temperature values can be found in July, while the lowest in December (Fantinato et al. 2019c).

Sampling sites were represented by small- to medium-sized (0.2–2 ha) dry grasslands, dispersed in an agricultural landscape among forests and arable fields. Created by low-intensity agricultural land use, semi-natural dry grasslands represent unique and species-rich plant assemblages. Temperate dry grasslands are maintained by traditional management practices as mowing, pasturing and haymaking (Habel et al. 2013), which regulate species composition and richness (Valkó et al. 2012). When low-intensity agricultural regimes are maintained, dry grasslands host important orchid populations (Fantinato et al. 2016a, 2016b, 2017; Slaviero et al. 2016). Abandonment results in structural changes such as the development of thermophilous fringe vegetation and scrubland facies (Biondi et al. 2006; Slaviero et al. 2016), with possible impacts on orchid populations (Slaviero et al. 2016).

Target species

Himantoglossum adriaticum is a European endemic species of priority interest (Directive 92/43/ EEC, Annex II), suffering population decline in many European countries (Dostalova et al. 2013). Its range comprises Austria, Bosnia-Herzegovina, Croatia, Czech Republic, Hungary, Italy, Slovakia, and Slovenia (Dostalova et al. 2013). It is described in the global IUCN Red List (Dostalova et al. 2013) and in the Italian Red List (Rossi et al. 2013) as LC (Least Concern). At regional level (Buffa et al. 2016) the species is classified as NT (Near Threatened), but its status worsens in lowland areas. In Northern Italy, it is mostly found in dry grasslands and nearby ecotonal meso-xeric scrubland/woodland patches (Slaviero et al. 2016; Del Vecchio et al. 2019).

H. adriaticum is a robust, perennial, tuberous, orchid with an over-wintering rosette composed of lanceolate, pale green basal leaves. The generative shoots are on average 40–80 cm tall, but they can reach 120 cm. The inflorescence is elongate and lax, composed of several (15–40) flowers and typically 14–24 cm in length (Bódis et al. 2019).

The labellum is the main characteristic that differentiates *Himantoglossum* species (Perazza and Lorenz 2013). In *H. adriaticum*, the violet trilobal labellum can reach 7 cm in length, the central lob has some tufts of purple hairs while the laterals are very thin and shorter. The flowering season usually starts in May or June. Its pollination system is rather generalised (Fantinato et al. 2017). *H. adriaticum* is normally found in light to semi-shaded habitats (Delforge 2006), where it takes advantage of shadows produced by shrubs or slopes to avoid direct sunlight and drought conditions. However, if shrubs become dominant thereby increasing shadow, *H. adriaticum* can suffer limited growth or even local population extinction (Tornadore et al. 2006).

Data collection

We selected seven populations of *H. adriaticum*; three at the Euganei Hills and four at the Berici Hills. Between the 1st and the 10th of June, we placed a plot of 2 m × 2 m at the core of each population. In each plot, the plant community attributes were described by recording the composition of vascular plant species and visually estimating the percentage cover and average height of the herb and shrub layer (C_h and C_s; H_h and H_s, respectively). To account for geomorphic variability, in each plot topographic data were collected: aspect (AS), expressed in degrees clockwise from the North and slope (SL), measured in percentage steepness with respect to the horizontal plane (steepness = 0%).

Given the threatened status of the species, we restricted the sampling to a low number of individuals per population (less than 15% of the overall individuals' abundance) in order to avoid negative impacts on the populations' persistence (Astuti et al., 2019). We collected individuals by cutting the stem at 1 cm from the ground and we rehydrated them for 24 hours to reach full turgidity. For each individual, we measured the maximum vegetative height, i.e. the height of the whole foliage (MH) and we chose at least two undamaged and well-developed leaves for the subsequent measurements (Pérez-Harguindeguy et al. 2013). Laboratory measurements followed the standardized methodologies detailed by Pérez-Harguindeguy et al. (2013). We determined leaf fresh weight (LFW) and leaf area (LA, i.e. a single-sided leaf area with petiole). LA was determined using the Leaf Area Measurement Software (Askew 2003). Leaf dry weight (LDW) was then determined following drying for 72 h at 60 °C, and the specific leaf area (SLA; the ratio of leaf area to leaf dry mass) and the leaf dry matter content (LDMC; the ratio of leaf dry mass to fresh mass) were calculated.

LA, LDMC and SLA provide strong indications about vascular plant adaptations under different environmental conditions and are at the basis of the calculation of the CSR strategies (Pierce et al. 2013). They can be defined as follows.

- ***Leaf area (LA)***: it is the size of the photosynthetic organ. It measures how much a plant invests in the photosynthesis. The leaf area is directly linked to the plant capacity to intercept light, and hence to the plant productivity. Leaf area can vary with changes in climate, altitude, and stress, such as soil aridity. LA decreases under increasing stressful conditions (Pérez-Harguindeguy et al. 2013).
- ***Leaf dry matter content (LDMC)***: it quantifies leaf tissue density and nutrient retention capacity. High values of LDMC indicate a preference in conserving nutrients. Species with high level of LDMC show tough leaves, highly resistant to hazards (Freschet et al. 2010; Lienin and Kleyer 2012).
- ***Specific leaf area (SLA)***: it is defined as the ratio of total leaf area to total leaf dry mass. In other words, it describes the amount of leaf area for light capture per unit of biomass invested. High SLA values are generally recorded in resource-rich environments, while low values in resource-poor environments (Pérez-Harguindeguy et al. 2013; Freschet et al. 2010).

Data analysis

We used the canonical correspondence analysis (CCA) to study the relationship between plant traits, plant community attributes and plot geomorphological features. In the CCA ordination, the sample units were the individuals of *H. adriaticum* collected in each population. We used values of LDMC, SLA and the maximum height of the whole foliage (MH) as dependent variables, while the percentage cover and average height of the herb and shrub layer (C_h and C_s; H_h and H_s), plot aspect (AS) and slope (SL) as predictor variables. We used 1,000 Monte Carlo permutations to assess statistical significance of the association between plant traits, plant community attributes and plot geomorphological features. To define the groups in the CCA diagram we performed a cluster analysis on the plots × plant community attributes (using average-linkage method and Bray–Curtis distance).

The relative contribution (%) of C, S, and R parameters to the tertiary CSR strategy was automatically calculated and represented by a ternary plot using the spreadsheet provided by Pierce et al. (2017). The CSR classification investigates the trade-off between the traits LA, LDMC and SLA (high values of these traits are mutually-exclusive and represent extremes of leaf economic and size) to calculate the relative proportion of C-, S- and R-selection exhibited by the species. We quantified the relative contribution (%) of C, S, and R parameters to the tertiary CSR strategy for each sampled leaf and results were averaged per individual. In order to evaluate intraspecific trait variability, in terms of percentage of C, S and R parameters, among individuals of *H. adriaticum* growing in the different groups revealed by the cluster analysis, we performed a one-way PERMANOVA applying the Bray–Curtis similarity index with 9,999 (Anderson and Ter Braak 2003; Past 3.0 Software). Then, the Tukey HSD test was used to determine which parameters differed between the two groups.

Results

We sampled 29 individuals of *H. adriaticum*. The number of sampled individuals varied from 1 to 15, with an average number of 4.5 ± 5.2 (mean ± SD) individuals per population (Table 1).

The two CCA axes explained 88.81% ($p = 0.018$) and 11.19% ($p = 0.002$) of the variance, respectively (Trace = 0.021; $P < 0.001$). The first CCA axis was strongly positively related to the percentage cover of the herb (C_h; 0.71) and shrub layer (C_s; 0.63), to the average high of the shrub layer (H_s; 0.62) and to the plot slope (SL; 0.53). The largest loadings on the second axis were from plot aspect (AS; -0.27) and slope (SL; 0.25). The CCA revealed a strong positive relationship between SLA, community attributes (i.e., C_h, C_s, H_h and H_s) and plot geomorphological features (i.e., AS and SL; Fig. 1), and a slightly negative relationship between LDMC, community attributes and plot geomorphological features (Fig. 1). The cluster analysis highlighted that sampled plots belonged to two distinct groups; the first corresponding to flat, managed grasslands without shrubs, while the second to steep, abandoned grasslands, highly encroached by shrubs (Table 1).

The overall strategy of *H. adriaticum* obtained by averaging single individual strategy irrespectively of the habitat type was CR (C:S:R; 60:0:40 %). Significant differences in the CSR strategy of *H. adriaticum* growing in managed vs. abandoned dry grasslands were revealed by PERMANOVA ($F= 28.4$; d.f. = 40.71; $P < 0.0001$). Tukey test revealed that individuals of *H. adriaticum* growing in managed dry grasslands showed a significantly higher percentage of the C parameter ($P < 0.0001$; Fig. 2), and a significantly lower percentage of the R parameter ($P < 0.0001$; Fig. 2) than those growing in abandoned dry grasslands (Table 2).

In other words, our results suggest that individuals of *H. adriaticum* show different strategies when growing in different habitats (Fig. 3). In our study, individuals growing in managed dry grasslands were more competitive than individuals growing in abandoned dry grasslands, which, on the contrary, were more ruderal.

Discussion

Plant traits are increasingly used to detect plant responses to changes in environmental conditions, since they allow to determine species ecological roles in the environment (Violle et al. 2007) and to detect their ecological strategies (Grime and Pierce 2012; Pierce et al. 2017). Based on the results of this study, leaf traits and Grime's (1974; 1977) theoretical triangular scheme of competitor, stress tolerator and ruderal plant strategies (CSR theory) proved to be applicable for assessing the functional strategies at intraspecific level.

According to Delforge (2006), *H. adriaticum* is a species of light or semi-shaded habitats on shallow rocky soils with neutral or basic reaction. It does not show any strong phytocoenological preference. Its primary habitat includes dry grasslands (*Festuco-Brometea* Br.-Bl. & Tüxen ex Br.-Bl. 1949 class) and open shrubby communities (*Rhamno-Prunetea* Rivas Goday & Borja ex Tüxen 1962 class) with a mosaic of fully sunny and shaded patches (Bódis et al. 2019), however it can persist in a wide range of habitats including mesic grasslands (*Molinio-Arrhenatheretea* Tüxen 1937 class), and can also colonise secondary habitats such as roadsides or abandoned vineyards (Fekete et al. 2017).

Overall, *H. adriaticum* exhibited a Competitive-Ruderal (CR) secondary strategy, incorporating substantial competitive and, to a lesser extent, ruderal features. Interestingly, neither the species nor the two groups of individuals showed the stress-tolerant component. This low

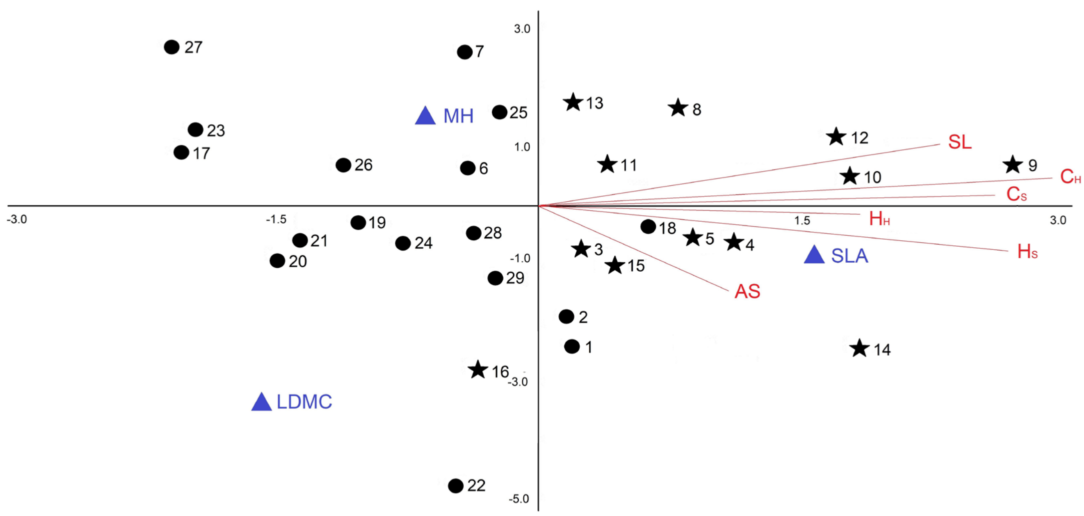

Figure 1. Scatterplot of the canonical correspondence analysis (CCA) utilized to investigate the relationship between plant traits (blue triangles), plant community attributes and plot geomorphological features (red lines). Different symbols indicate individuals of *H. adriaticum* growing in managed (black dots) or in abandoned grasslands (black stars), as revealed by the cluster analysis.

Table 1. Plant community attributes and geomorphological features of sampled populations.

Population ID	Sampling site	Total number of individuals	Number of sampled individuals	Aspect (degrees)	Slope (%)	Herb layer cover (%)	Shrub layer cover (%)	Herb height (cm)	Shrub height (cm)	Management regime
1	Euganei	15	2	315	5	70	-	20	0	Managed
2	Euganei	115	13	45	5	40	-	25	0	Managed
3	Euganei	96	3	0	0	90	30	20	300	Abandoned
4	Berici	15	2	90	35	100	28	70	200	Abandoned
5	Berici	23	1	135	20	65	50	40	250	Abandoned
6	Berici	62	3	135	15	80	65	40	180	Abandoned
7	Berici	101	3	135	10	75	50	30	400	Abandoned

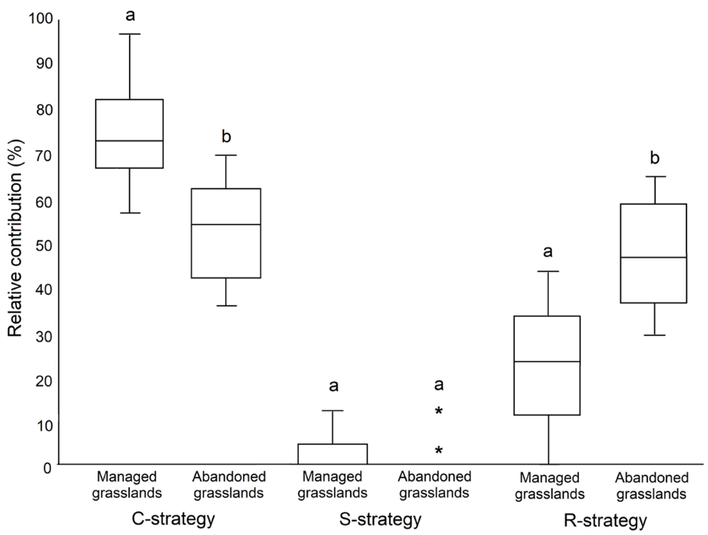

Figure 2. Differences in the relative contribution (%) of C, S and R parameters, among individuals of *H. adriaticum* growing in managed vs. abandoned grasslands. Different letters indicate significant differences according to Tukey's test.

inclination for the S- strategy may be explained by the particular phenology of *H. adriaticum*. Contrary to other dry grassland orchid species, its growing period starts in late spring, and the time of flowering is usually around late May or June. The capsules mature in 4–6 weeks, and seeds are shed rather quickly, in July or August (Bódis et al. 2019). This period corresponds with the rainfall season in the study area, with the average peak of rain in April; at the same time, temperatures, although increasing, do not have reached their peak, which is in July (Fantinato et al. 2017). Thus, *H. adriaticum* can take advantage of climatic conditions that allow it to complete its life cycle without incurring in stress conditions. Conversely, its characteristic perennial features and persistent rootstock account for the species' ability to compete and allow a rapid growth and development of a large standing biomass.

Despite these general characteristics, the CCA ordination showed that specific leaf area (SLA) and leaf dry matter content (LDMC) of *H. adriaticum* varied along with community attributes and plot geomorphological features, reaching, respectively, the highest and the lowest values in partially shaded, sloping grasslands encroached by shrubs. These traits are known to reflect crucial life history

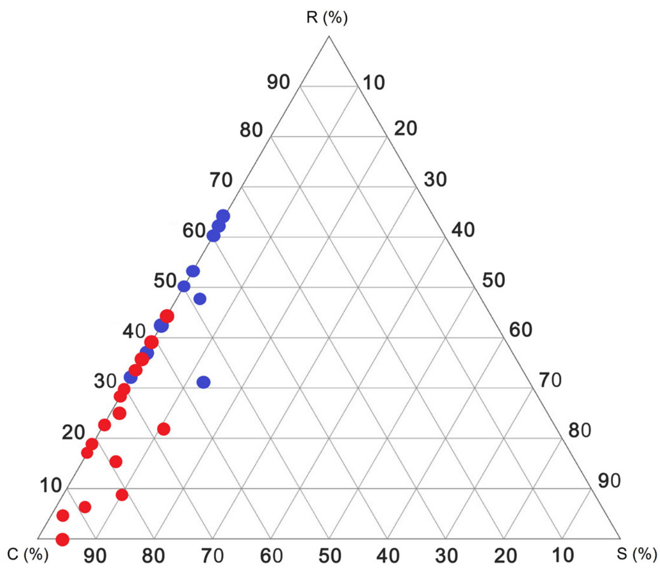

Figure 3. CSR triangular scheme for the individuals of *H. adriaticum* growing in managed (red dots) and abandoned grasslands (blue dots).

Table 2. Trait values and CSR strategy of sampled individuals of *H. adriaticum*.

ID	Maximum vegetative height (cm)	LA (mm^2)	LDMC (%)	SLA (mm^2 mg^{-1})	%C	%S	%R	Tertiary strategy
Managed grasslands								
1	22.7	2.347.033	9.937	17.685	77.43	0	22.57	C/CR
2	27.4	1.935.357	11.290	20.531	67.94	0	32.06	C/CR
6	38.7	1.869.641	11.597	21.933	64.49	0	35.51	C/CR
7	45.2	1.766.543	10.141	23.411	61.14	0	38.86	C/CR
17	40.6	2.936.839	12.720	12.847	95.71	4.29	0	C
18	31.1	1.346.199	10.101	24.798	56.52	0	43.48	CR
19	33.9	1.804.074	11.796	16.346	81.46	0	18.54	C
20	33.7	2.301.610	12.784	14.276	89.15	4.69	6.159	C
21	35.2	1.091.375	12.789	15.440	79.25	5.38	15.37	C
22	24.2	1.315.645	13.901	17.281	67.44	10.9	21.7	C/CR
23	45.6	1.672.339	13.610	14.696	80.97	10.1	8.909	C
24	34.0	1.755.570	12.237	18.075	73.72	1	25.28	C/CR
25	35.8	1.650.154	9.290	20.705	66.4	0	33.6	C/CR
26	36.0	2.073.885	11.139	16.157	82.95	0	17.05	C
27	49.1	2.709.226	12.363	14.069	93.29	1.94	4.776	C
28	32.7	1.809.762	11.325	19.574	70	0	30	C/CR
29	28.5	1.531.902	10.782	18.836	71.08	0	28.92	C/CR
Abandoned grasslands								
ID	**Maximum vegetative height (cm)**	**LA (mm^2)**	**LDMC (%)**	**SLA (mm^2 mg^{-1})**	**%C**	**%S**	**%R**	**Tertiary strategy**
3	29.4	2.381.676	9.724	21.063	68.02	0	31.98	C/CR
4	29.4	2.067.571	9.769	26.650	57.07	0	42.93	CR
5	27.0	1.934.965	9.010	22.896	62.78	0	37.22	C/CR
8	38.7	1.547.654	9.624	30.906	49.52	0	50.48	CR
9	45.2	854.140	7.471	40.698	35.96	0	64.04	R/CR
10	41.2	1.018.072	10.568	40.301	37.84	0	62.16	R/CR
11	32.3	2.131.742	9.468	23.533	62.28	0	37.72	C/CR
12	39.5	868.181	8.752	35.873	39.62	0	60.38	R/CR
13	33.4	1.184.001	9.111	23.704	57.33	0	42.67	CR
14	37.4	1.404.920	11.609	32.653	46.9	0	53.1	CR
15	37.2	1.273.419	13.051	28.582	48.44	4.23	47.33	CR
16	27.2	2.379.992	15.152	22.667	56.45	12.7	30.87	C/CR

trade-offs between the investment of resources in further resource acquisition vs. conservation (Pierce et al. 2017). High values of SLA ensure for high rates of resource acquisition in productive habitats, while high values of LDMC indicate a conservative leaf economics, implying the acquisition of traits responsible for retention of resources in unproductive conditions. Thus, strategies arise as an adaptive response of plants to site ecological condition (Cerabolini et al. 2010), and our results suggest that individuals of *H. adriaticum* develop different strategies when growing in different habitats. Specifically, individuals growing in managed fully sunny dry grasslands had lower values of SLA and a higher relative contribution of the C parameter than individuals growing in abandoned dry grasslands, which, on the contrary, had higher values of SLA (and correspondingly lower values of LDMC) and a higher relative contribution of the R parameter. The relatively higher ruderal component of individuals of *H. adriaticum* growing in abandoned dry grasslands, may be explained considering the local geomorphological characteristics. Dry grassland abandonment started from steep slopes, where management practices were more difficult. Steep slopes are generally characterized by high levels of natural disturbance, such as accelerated erosion processes from stormwater runoff and soil loss, with vegetation destruction and fragmentation. Under these unstable environmental conditions, individuals of *H. adriaticum* may have been selected according to their strategy, with the ruderal component being favoured on the competitive one.

We are aware that the number of individuals addressed in this study is rather low, and that our conclusions may not be considered of general validity for the species. However, as reported by Astuti et al. (2019), in the case of rare and threatened species, the use of small samples can be justified for conservation purposes. Although further research is needed to disentangle to what extent the morphological and ecological variability of the species is due to phenotypic plasticity or genetic variability of the populations, these results are stimulating as they show that plant species present adaptations to changing environmental conditions and extant community attributes that can be detected through the CSR scheme, at a very small spatial scale. Moreover, and consistently to other previous studies (e.g. May et al. 2017; Giupponi and Giorgi 2019), this research confirms that all components (Competitive, Stress tolerant and Ruderal component) of the CSR functional strategy can vary significantly among individuals of the same species. In this regard, a further step towards the comprehension of processes underlying patterns of trait variation should account for regeneration traits of *H. adriaticum*. Trait-based ecology has so far mainly focused on adult plants despite early stages of a plant life history being very sensitive to environmental factors (Fantinato et al. 2018; Del Vecchio et al. 2020a, 2020b). Specifically, beside differing in leaf traits, the two components (competitive and ruderal) also vary in trade-offs of resource allocation to seed production, with competitors primarily composed of species with relatively low seed production and ruderals allocating resources mainly to seeds. Thus, reproductive traits and precisely fruit and seed-set may corroborate our results.

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PENSOFT.

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Vegetation of the "Altipiani di Colfiorito" wetlands (central Apennines, Italy)

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Abstract

The "Altipiani di Colfiorito" catchment basin in central Italy features a wetland system of great interest for conservation, composed of seven plains. Considering that most of the relevés conducted in the past refer to one plain and date back to the 1960s, the research aim was to widen and update the vegetation knowledge in the whole wetland system. Two hundred and thirty-nine phytosociological relevés were carried out using the Braun-Blanquet method. On the basis of cluster analysis of the species data set and phytosociological interpretation, 39 vegetation types were classified, most of which of high conservation interest in central Italy, referred to the *Potamogetonetea* (6 communities), *Bidentetea* (2), *Phragmito-Magnocaricetea* (21), *Molinio-Arrhenatheretea* (9), and *Epilobietea angustifolii* (1) classes. The new subassociation *Phalaridetum arundinaceae alopecuretosum bulbosi* is also described. Twenty-two communities found in the past decades by other authors were confirmed, while 17 were new records for the study area. Ten communities were attributed to four habitats of community interest according to the 92/43/EEC Directive, coded as 3150, 3260, 3270, and 6510. Twenty-four communities were not confirmed (eight of *Charetea*, *Lemnetea minoris*, and *Potamogetonetea*, one of *Bidentetea*; seven of *Phragmito-Magnocaricetea*; three of *Scheuchzerio-Caricetea fuscae*, four of *Molinio-Arrhenatheretea* and one of *Isoëto-Nanojuncetea*). Three habitats of community interest (3140, 3170*, and 7230) were not confirmed.

Keywords

central Italy, habitats of community interest, humid meadows, lacustrine habitat, marshland, nature conservation

Introduction

Wetlands represent important ecosystems at the European level (Landucci et al. 2015). The central Apennine (Italy) wetland systems of tectonic-karstic basins are important hotspots of plant and animal biodiversity (Ciaschetti et al. 2020), but management abandonment and such anthropic pressures as drainage, water extraction, tillage, and excavations have greatly reduced their extent and worsened their conservation status (Pedrotti 1965, 1996, 2019; Ballelli et al. 2010; Catorci et al. 2010).

The "Altipiani di Colfiorito" catchment basin hosts one of the most important wetlands of central Italy and is highly worthy of conservation because of its landscape, plant and animal biodiversity, and ecology (Orsomando and Catorci 1998; Renzini 1998; Tardella 2007). This area includes a wetland protected by the Ramsar Convention, an Important Bird Area, three Special Areas of Conservation, and a Special Protection Area of the Natura 2000 network, according to the 92/43/EEC Directive. Since 1995, part of this wetland system has been included in the Parco di Colfiorito, a Regional Park of Umbria.

Several authors (e.g. Pedrotti 1965, 1996, 2019; Ballelli et al. 2001; Brusaferro et al. 2008; Catorci et al. 2010; Lastrucci et al. 2017a, b, 2019a) pointed out the modifications of this wetland in the past decades, which have led to the reduction in extension, worsening of conservation status or local extinction of rare and endangered plant communities, some of which deemed habitats of community interest (Biondi et al. 2010). Moreover, this wetland system includes the Habitat "C1.6a Temperate temporary waterbody" that, although is qualified for Least Concern in the European Red List of habitats and, thus, is not deemed threatened at the European level, in Italy has a declining trend in extent and quality (Janssen et al. 2016).

Most of the studies about the vegetation of this district have been conducted at the Palude di Colfiorito, in the central part of the catchment basin, since the 1960s by Pedrotti, who published the vegetation map (Pedrotti 1975) and the related phytosociological relevés (Pedrotti 2019), which date back to the years 1963-1968, along with some new relevés (Pedrotti 2019; Pedrotti and Murrja 2020). Some other relevés at the Palude di Colfiorito have been published by Pedrotti (1979), Buchwald (1992, 1994), and Lastrucci et al. (2017a). A few relevés are available for the other wetlands (Aleffi and Cortini Pedrotti 1995; Pedrotti 2019).

Considering that the plant sociology of plant communities in the whole system of the "Altipiani di Colfiorito" had never been exhaustively analysed and that most of the relevés conducted in the past refer to the only Palude di Colfiorito and date back to the 1960s, the research goal was to classify the plant communities that compose the vegetation of the wet environments, widening and updating the vegetation knowledge of the wetland system.

Methods

Study area

The study area, known as the "Altipiani di Colfiorito", is located between Umbria and Marche in central Italy (Fig. 1) (coordinate range 42° 59.40'–43° 04.50' N, 12° 50.30'–12° 55.80' E), at altitudes ranging from 750 to 810 m a.s.l., and consists of seven plains, named the Palude di Colfiorito, Piano di Colfiorito, Piano di Popola e Cesi, Piano di Annifo, Piano di Arvello, Piano di Colle Croce, and Piano di Ricciano (Appendix I).

In terms of bioclimate, the study area is in the lower supratemperate bioclimatic belt, whose thermotype is lower supratemperate and the ombrotype is lower humid (Pesaresi et al. 2017); the mean annual temperature ranges from 11 to 13 °C and the mean annual precipitation from 1000 to 1100 mm (Orsomando et al. 2000).

The geological substratum is composed of limestones and the plains are covered by lake and marshy deposits, such as gravel, clay, silty clay, and peat (Materazzi and Pieruccini 2001). Soils are deep, hydromorphic, subacid, rich in organic matter, with silty clayey texture and scarce or absent skeleton (Giovagnotti et al. 2003).

The water supply is mainly provided by rainfall, which is maximum in autumn-winter-spring and minimum in summer, while only a small part derives from some torrent waterways and small springs. This rainfall trend determines significant water level fluctuations, namely the increase of the water-covered areas for short periods, followed by their drainage in summer. Swallow holes at the borders of the plains are the only form of natural drainage and are a surface effect of underground karstic phenomena. A hydric system composed of artificial canals and ditches of moderate depth drains water to swallow holes.

The plains are mainly covered by aquatic and marsh vegetation, humid hay meadows, and arable lands, cultivated mainly with wheat, barley, spelt, lentils, and potatoes, alternated with copses of woody hygrophilous vegetation. The areas between the plains and slopes of the surrounding mountains host agricultural land, small mixed woodlands with *Quercus cerris* and *Carpinus betulus* and with *Q. cerris* and *Ostrya carpinifolia*, hay meadows, and dry grasslands (Orsomando and Pambianchi 2002).

Land use history and anthropic pressure

The study area has a long land use history. Artificial underground drainage systems were built about two thousand years ago by the Romans and, more recently (1458-1464) by the Da Varano Dukes. The latter, called "Botte dei Varano", caused the complete drainage of the Piano di Colfiorito that until then had hosted a lake (Mengozzi 1781; Pedrotti 2019). Between 1492 and 1631 numerous attempts were carried out to drain the Palude di Colfiorito, by excavating and progressively enlarging the swallow holes, digging canals and ditches, but they never succeeded in the complete reclamation of the basin (Sensi 1998; Pedrotti 2019). Even in the last century, the Palude di Colfiorito was subjected to numerous attempts of reclamation to widen the extent of croplands (Lip-

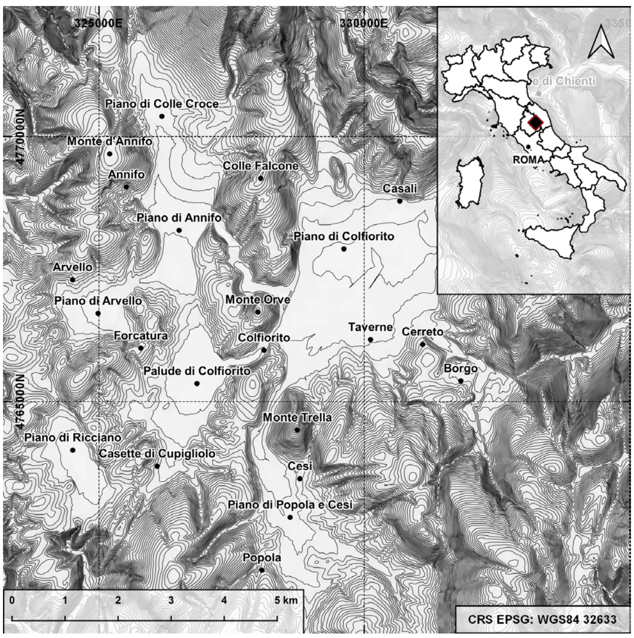

Figure 1. Location of the "Altipiani di Colfiorito" (central Italy).

pi-Boncambi 1940; Pedrotti and Pettorossi 1968, 1969; Pedrotti 2019). Photographic documentation of the Palude di Colfiorito shows that in the 1940s-early 1950s, this wetland was almost completely flooded during the rainy part of the year, appearing as a lacustrine area surrounded by a belt of *Phragmites australis* and *Schoenoplectus lacustris*, and was indeed called Lake of Colfiorito (Brusaferro et al. 2008; Catorci et al. 2010; Pedrotti 2019). The reed was contained by flame weeding to foster the presence of anatids for hunting purposes (Brusaferro et al. 2008). The extent of the coenoses of the *Phragmition communis* was changeable depending on the water amount and anthropic pressure, whereas, in the outer part of the basin, there was herbaceous vegetation (Pedrotti 2019). The free waters in the central part of the basin in the mid of the reed bed hosted hydrophytic communities characterized by *Potamogeton lucens*, *Nymphaea alba*, *Persicaria amphibia*, and *Characeae* (Pedrotti 2019).

Between 1964 and 1972, the vegetation of a peat bog, composed of *Eriophorum latifolium*, *Carex panicea*, and *Juncus subnodulosus* communities, along with *Magnocaricion elatae* communities and part of *Ranunculion velutini* hay-meadows, were destroyed to plant a poplar (*Populus canadensis*) cultivation, and then drained, tilled, and subjected to peat mining (Pedrotti 1965, 1977, 2019).

From the early 1970s, when hunting was prohibited and the periodical flame weeding ceased, to the end of the 20th century, the reed doubled its surface to the detriment of hydrophytic communities and *Schoenoplectetum lacustris* (Pedrotti 1975; Orsomando 2002; Catorci et al. 2010), while the vegetation of *Trifolio-Hordeetalia* reduced its extent (Pedrotti 2019).

In the early 1990s, the thresholds of the bulkheads in front of the three main swallow holes were raised, and gaps in the helophytic vegetation were opened near the borders of the basin (Pedrotti 1996). This intervention had the positive effect of limiting the frequency of desiccation events during summer. However, in the last 20 years, the Palude di Colfiorito underwent several times desiccation, probably because of the reduction of precipitation and the increase in evapotranspiration due to the spread of the reed bed (Brusaferro et al. 2008; Catorci et al. 2010).

Since the institution of the Colfiorito Regional Park, the anthropic pressure ceased; however, the reed bed spread, closing some canals and ditches, and accumulated a great amount of litter, causing negative impacts on the wetland ecosystem (Brusaferro et al. 2008; Catorci et al. 2010). The *Nymphaeetum albae* spread as well, and a shrub formation now covers the area formerly covered by the peat bog vegetation (Pedrotti 2019).

Recently, Lastrucci et al. (2019a) recorded at the Palude di Colfiorito a net 18.8% increase in the surface of the reed bed between 1988 and 2012 due to the expansion of the reeds in terrestrial habitats formerly covered by different types of natural vegetation. However, they reported a retreat of the reed bed from the waterfront and an increasing fragmentation associated with the reed dieback process (Lastrucci et al. 2017b, 2019a).

The privately-owned lands occupied by humid hay meadows around the marsh, as well as in the other plains, are traditionally mown twice during the year (late June/early July and late August). The use of fertilizers in the surrounding arable lands has been deemed as the main cause of water eutrophication in the Palude di Colfiorito, where the quality of water between 2004 and 2011 was frequently considered as poor or bad, with low oxygen concentrations during summer (Regione Umbria 2015).

Data collection

We conducted 239 phytosociological relevés (years 2005-2009) using the Braun-Blanquet phytosociological method (Braun-Blanquet 1964). The species nomenclature followed Bartolucci et al. (2018). For each relevé, we recorded the following data: collection date, locality, altitude (m a.s.l.), slope aspect (azimuth degrees), slope angle (vertical degrees), total vegetation cover (%), and cover-abundance values of the species, the latter assigned using the Braun-Blanquet scale (Braun-Blanquet 1964). Localities are indicated in the tables (Supplementary material 1: Tables S1-S19) using the following abbreviations: An, Piano di Annifo; Ar, Piano di Arvello; Cc, Piano di Colle Croce; Co, Piano di Colfiorito; PC, Palude di Colfiorito; P, Piano di Popola e di Cesi; R, Piano di Ricciano. The dates of relevés are listed in Appendix II.

Data elaboration

We transformed Braun-Blanquet cover-abundance classes into percent values using the average cover values of Braun-Blanquet classes:

+ (< 1%), 0.5 %;
1 (1–5%), 3 %;
2 (5–25%), 15%;
3 (25–50%), 37.5%;
4 (50–75%), 62.5%;
5 (75–100%), 87.5%.
r (rare species) were attributed 0.1%.

We performed cluster analysis on the Hellinger-transformed "relevé-by-species cover" matrix, using the group average algorithm, based on euclidean distance. The Hellinger transformation is recommended for the classification and ordination of species abundance data (Rao 1995; Legendre and Gallagher 2001). To perform cluster analysis, we used R software (version 3.4.1, R Foundation for Statistical Computing, Vienna, Austria, 2017, http://www.R-project.org) and the hclust function of the *stats* R-package, version 3.4.1, as well as the vegdist function of the *vegan* R-package, version 2.4-3 (Oksanen et al. 2017). To perform the Hellinger transformation, we used the decostand function of *vegan*.

For the syntaxonomic placement of the vegetation types, we referred to Chytrý (2011), Landucci et al. (2013, 2015, 2020), Biondi and Blasi (2016), Mucina et al. (2016), Venanzoni et al. (2018), and Ciaschetti et al. (2020). The nomenclature of alliances and higher syntaxonomic ranks was taken from Mucina et al. (2016). For nomenclature at the association level, we referred mainly to Chytrý (2011) and Landucci et al. (2020).

Finally, we compared the plant communities found in our survey with those found by other authors in the past in the study area and assessed their status as habitats of community interest sensu 92/43/EEC Directive following the Italian interpretation manual of the 92/43/EEC Directive habitats (Biondi et al. 2010).

Results

The cluster analysis of the phytosociological relevés showed the following nineteen main groups (Fig. 2), some of which were further divided into sub-clusters depending on their floristic characteristics: rooting hydrophytic communities dominated by *Myriophyllum spicatum*, *Persicaria amphibia*, *M. verticillatum*, *Nymphaea alba* (group 1, Suppl. material 1: Table S1) or *Callitriche stagnalis* (group 2, Suppl. material 1: Table S2); rooting hydrophytic communities with a dominance of *Ranunculus trichophyllus*, and helophytic vegetation with a dominance of *Glyceria notata* (group 3, Suppl. material 1: Table S3); helophytic communities dominated by *Berula erecta*, *Catabrosa aquatica*, *Veronica anagallis-aquatica*, *Nasturtium officinale* or *Helosciadium nodiflorum* (group 4, Suppl. material 1: Table S4), *Eleocharis palustris* (group 5, Suppl. material 1: Table S5), *Schoenoplectus lacustris*, *Limniris pseudacorus*, *Typha latifolia*, *Carex hirta*, *Glyceria maxima* (group 6, Suppl. material 1: Table S6), *Carex vesicaria* (group 7, Suppl. material 1: Table S7), *Juncus inflexus* subsp. *inflexus* (group 8, Suppl. material 1: Table S8); *Sambucus ebulus*-dominated perennial nitrophilous vegetation (group 9, Suppl. material 1: Table S9); helophytic communities characterized by *Carex riparia*, *Cyperus longus* or *Phragmites australis* (group 10, Suppl. material 1: Table S10); therophytic ephemeral nitrophilous communities dominated by *Xanthium italicum*, *Bidens tripartita* subsp. *tripartita* and *Persicaria lapathifolia* subsp. *lapathifolia* (group 11, Suppl. material 1: Table S11); perennial hygro-nitrophilous vegetation characterized by *Epilobium hirsutum* or *Galega officinalis* (group 12, Suppl. material 1: Table S12); grassland communities dominated by *Deschampsia cespitosa* (group 13, Suppl. material 1: Table S13) or *Ranunculus velutinus* (group 14, Suppl. material 1: Table S14); helophytic vegetation with a dominance of *Sparganium erectum* (group 15, Suppl. material 1: Table S15) or *Carex acuta* (group 16, Suppl. material 1: Table S16); *Potentilla reptans*-dominated perennial hygro-nitrophilous vegetation (group 17, Suppl. material 1: Table S17); *Phalaris arundinacea*-dominated helophytic vegetation (group 18, Suppl. material 1: Table S18); *Carex otrubae*, *Rorippa amphibia* or *Gratiola officinalis*-dominated communities (group 19, Suppl. material 1: Table S19).

Discussion

Phytosociological interpretation of plant communities

The phytosociological interpretation of plant communities highlighted by cluster analysis (Fig. 2) led to identifying 39 plant communities, described below according to their floristic, phytocoenological, and ecological features.

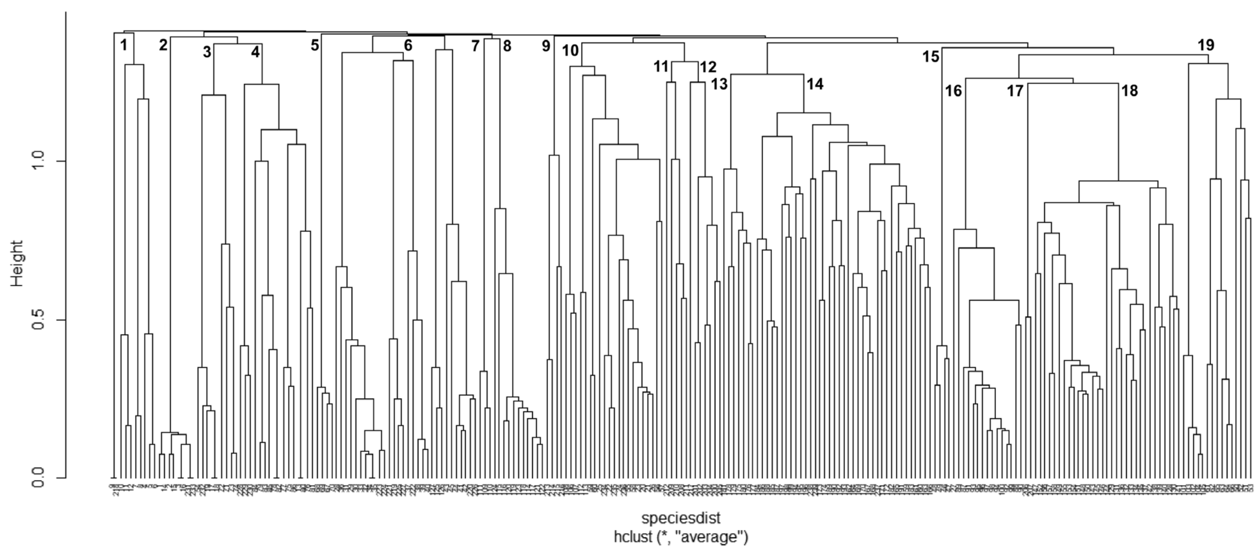

Figure 2. Dendrogram obtained from the cluster analysis of the "relevés-by-species" matrix. The cluster numbering corresponds to the table numbering in the supplementary material 1.

POTAMOGETONO PECTINATI-MYRIOPHYLLETUM SPICATI Rivas Goday 1964 (group 1, Suppl. material 1: Table S1, rels 1–2)

Hydrophytic vegetation characterized by the submerged species *Myriophyllum spicatum*, attributed to the *Potamogetono pectinati-Myriophylletum spicati* association (*Potamogetonion pectinati* alliance). This community, generally common in water bodies characterized by a high concentration of organic sediments (Barko and Smart 1986; Ceschin and Salerno 2008), is uncommon in the Palude di Colfiorito, where water depth exceeds 50 cm.

In 1967, Pedrotti found at the Palude di Colfiorito a *Myriophyllum spicatum*-dominated community, attributed to the *Myriophylletum spicati* association, which had a localized distribution (Pedrotti 2019).

The association was reported in lacustrine and fluvial environments in Italy, e.g. along the River Tiber (Lastrucci et al. 2012), at the Lakes of Massaciuccoli (Lastrucci et al. 2017c) and Martignano (Azzella et al. 2013). Although some authors (Minissale and Spampinato 1985; Pirone et al. 1997; Tomei et al. 2001; Brullo et al. 2001, 2002; Ceschin and Salerno 2008) reported *Myriophyllum spicatum* communities in central-southern Italy as *Myriophylletum spicati* and attributed them to the *Nymphaeion albae* alliance, we attributed this community to the *Potamogetonion pectinati* alliance following many European and Italian authors (e.g. Felzines 1983; Golub et al. 1991; Pedrotti 1991, 1995; Loidi et al. 1997; Brzeg and Wojterska 2001; Sburlino et al. 2008; Lastrucci et al. 2010a; Šumberová 2011a; Pedrotti 2019).

PERSICARIA AMPHIBIA community (group 1, Suppl. material 1: Table S1, rels 3–5)

Hydrophytic species-poor community dominated by *Persicaria amphibia*, with *Myriophyllum verticillatum* and ingressive species from the *Phragmito-Magnocaricetea* class (*Phragmites australis*, *Mentha aquatica* subsp. *aquatica*, and *Carex acuta*).

We found this community of the *Nymphaeion albae* alliance, in the stagnant waters of the Palude di Colfiorito, with water depth ranging from a few centimeters to 50 cm during the year.

Persicaria amphibia communities have been reported from north-eastern Italy (Sburlino et al. 2008), in Lake Bolsena (Latium) (Iberite et al. 1995), Valdichiana and along the River Arno (Tuscany) (Lastrucci et al. 2007, 2010a,b), in Umbria and Abruzzo (Buchwald 1994; Orsomando 2002; Landucci et al. 2011), and in Sicily (Brullo et al. 1994).

MYRIOPHYLLETUM VERTICILLATI Gaudet ex Šumberová in Chytrý 2011 (group 1, Suppl. material 1: Table S1, rels 6–7)

Hydrophytic vegetation characterized by *Myriophyllum verticillatum*, a submerged species occurring in meso-eutrophic waters.

This community, attributed to the *Myriophylletum verticillati* association (*Potamogetonion pectinati* alliance), occurs in habitats in an advanced stage of terrestrialization (Šumberová 2011b) and is quite common in stagnant waters of the Palude di Colfiorito (water depth ranging from a few centimeters to more than half a meter). This community was sporadic at the end of the 1960s (Pedrotti 2019). In Italy, this association is uncommon, occurring in Latium (Ceschin and Salerno 2008), Tuscany (Lastrucci et al. 2016), and Sicily (Brullo et al. 1994, 2002; Raimondo et al. 2000).

NYMPHAEETUM ALBAE Vollmar 1947 (group 1, Suppl. material 1: Table S1, rels 8–10)

Species-poor hydrophytic vegetation, dominated by *Nymphaea alba*, sometimes with *Myriophyllum verticillatum* and *Persicaria amphibia*. Following Šumberová (2011a) and Tomaselli et al. (2006), we attributed this community to the *Nymphaeetum albae* Vollmar 1947 association (*Nymphaeion albae* alliance). We found this community in the stagnant waters of the Palude di Colfiorito, 0.5-1 m-deep, where it forms very extensive stands. This is consistent with Šumberová (2011a), who stated that this association significantly contributes to water body filling by its high biomass production.

According to Pedrotti (1975, 2019), *Nymphaea alba* occurred in the 1960s inside the subassociation *Myriophyllo-Potamogetonetum lucentis nymphaeetosum*.

The association was reported at the Lake of Massaciuccoli (Tuscany) by Lastrucci et al. (2017c), in Piedmont (Guglielmetto Mugion and Montacchini 1993-1994), Lombardy (Andreis and Zavagno 1996), Veneto (Anoè and Caniglia 1987), Trentino (Canullo et al. 1990), and Friuli-Venezia Giulia (Poldini 1989).

CALLITRICHE STAGNALIS community (group 2, Suppl. material 1: Table S2)

Hydrophytic vegetation dominated by *Callitriche stagnalis*, with *Ranunculus trichophyllus*, of the *Ranunculion aquatilis* alliance, with ingressive species from *Nasturtio-Glycerietalia* (*Nasturtium officinale*, *Helosciadium nodiflorum*, *Veronica anagallis-aquatica*, and *Berula erecta*).

We found this community in stagnant or slowly flowing waters of ditches; toward the banks, it was in contact with the helophytic vegetation of the *Helosciadietum nodiflori*, *Nasturtietum officinalis*, and *Veronica anagallis-aquatica* community.

Pedrotti (2019) found in the outer part of the Palude di Colfiorito, along spring-fed ditches, the *Veronico beccabungae-Callitrichetum stagnalis* Müller 1962, which differs from our relevés for the presence of *Veronica beccabunga* and *Glyceria fluitans*.

In accordance with some Italian authors (e.g. Corbetta and Pirone 1989; Baldoni and Biondi 1993; Venanzoni and Gigante 2000), we did not attribute *C. stagnalis*-dominated communities to the association *Callitrichetum stagnalis* Segal 1967, given their low floristic richness.

In Italy *C. stagnalis*-dominated communities have been found in the Venetian Plain (Marchiori and Sburlino 1997), Tuscany, Marche, Umbria, Latium, and Abruzzo (Corbetta and Pirone 1989; Baldoni and Biondi 1993;

Buchwald 1994; Venanzoni and Gigante 2000; Ceschin and Salerno 2008; Lastrucci and Becattini 2008; Mereu et al. 2010), and in Sardinia (Biondi and Bagella 2005).

POTAMOGETONO CRISPI-RANUNCULETUM TRICHOPHYLLI Imchenetzky 1926 (group 3, Suppl. material 1: Table S3, rels 1–5)

Ranunculus trichophyllus-dominated hydrophytic community, with *Callitriche stagnalis*, referred to the *Ranunculion aquatilis* alliance. The species composition included elements of the *Glycerio-Sparganion* alliance and higher-rank syntaxa (e.g. *Nasturtium officinale*, *Veronica anagallis-aquatica*, and *Glyceria notata*).

The association is uncommon in the stagnant or slowly flowing waters along ditches.

In Italy, *Ranunculus trichophyllus*-dominated communities were found in northeastern and central Italy, and in Sicily (e.g. Ferro 1980; Corbetta and Pirone 1989; Buchwald 1994; Gerdol and Tomaselli 1997; Tomei et al. 2001; Pirone et al. 2004; Tomasi and Caniglia 2004; Lastrucci et al. 2010a; Landucci et al. 2011).

GLYCERIETUM NOTATAE Kulczyński 1928 (group 3, Suppl. material 1: Table S3, rels 6–9)

Species-poor plant community, physiognomically characterized by *Glyceria notata* and other species of the *Glycerio-Sparganion* alliance and higher syntaxa (e.g. *Veronica anagallis-aquatica*, *Nasturtium officinale*, *Mentha aquatica* subsp. *aquatica*, and *Myosotis scorpioides*) and ingressive species from the *Potamogetonetea* class (*Ranunculus trichophyllus*).

The association is widespread in the ditches, in contact with the *Nasturtietum officinalis* association and the *Veronica anagallis-aquatica* community. In the sections with slow flowing water, it was found at the border of the watercourse, toward the inside, in contact with the *Potamogetono crispi-Ranunculetum trichophylli*. Where water is stagnant for most of the year, the community occupies the ditch bed, together with the *Caricetum vesicariae* and *Phalaridetum arundinaceae* associations.

In Italy this vegetation type is frequent, being recorded by many authors from sea level to the mountain belt (e.g. Cortini Pedrotti et al. 1973; Canullo et al. 1988; Corbetta and Pirone 1989; Pedrotti et al. 1992; Baldoni and Biondi 1993; Buchwald 1994; Pedrotti 1995; Marchiori and Sburlino 1997; Scoppola 1998; Biondi et al. 1999; Lastrucci et al. 2004; Pedrotti 2008).

BERULETUM ERECTAE Roll 1938 (group 4, Suppl. material 1: Table S4, rels 1–3)

Helophytic vegetation characterized by *Berula erecta*, with species of the *Glycerio-Sparganion* alliance and higher syntaxa (*Glyceria notata*, *Veronica anagallis-aquatica*, and *Nasturtium officinale*).

In the study area, it occurs along the ditches of the Palude di Colfiorito, near the banks of the deepest ones, where it is in contact with *Helosciadietum nodiflori*, towards the central part of the ditch section.

This community (syn. *Veronico-Sietum erecti* Passarge 1982, *Veronico beccabungae-Beruletum erectae* Passarge 1999) was found by Prosser and Sarzo (2003) and Pedrotti (1995) in Trentino, Pedrotti (2008) in the "Marcite di Norcia" (Umbria), by Ceschin and Salerno (2008) along the Rivers Tevere, Aniene and Treia (Latium), and in Molise (Canullo et al. 1988).

RORIPPO ANCIPITIS-CATABROSETUM AQUATICAE (Oberdorfer 1957) Müller et Görs 1961 (group 4, Suppl. material 1: Table S4, rel. 4)

Plant community with a dominance of *Catabrosa aquatica*, with *Veronica anagallis-aquatica*, *Glyceria notata*, and *Helosciadium nodiflorum*, growing on slow-flowing or temporarily stagnant waters. It hosts some species of the *Molinio-Arrhenatheretea* class, such as *Holcus lanatus*, *Poa pratensis* and *Dactylis glomerata*, because it is in contact with the temporarily flooded meadows of the *Ranunculion velutini* alliance. Following Landucci et al. (2020), the composition of this community fits with that of the *Rorippo ancipitis-Catabrosetum aquaticae* association (*Glycerio-Sparganion* alliance).

We found this community along the main ditch that crosses the Piano di Colle Croce.

The *Catabrosa aquatica* community found along the River Nera (Marche, central Italy) by Buchwald (1994), which was attributed to the *Catabrosetum aquaticae* Rübel 1911, should be referred to this association.

VERONICA ANAGALLIS-AQUATICA subsp. *AQUATICA* community (group 4, Suppl. material 1: Table S4, rels 5–9)

Veronica anagallis-aquatica-dominated community, with *Nasturtium officinale* and some ingressive species from the *Molinio-Arrhenatheretea* and *Bidentetea* classes. The occurrence of *Veronica anagallis-aquatica* and *Nasturtium officinale* justifies its placement in the *Glycerio-Sparganion* alliance.

The community was found in stagnant or slightly flowing waters, 20-50 cm deep, in contact with *Nasturtietum officinalis* and the *Callitriche stagnalis* community.

NASTURTIETUM OFFICINALIS Gilli 1971 (group 4, Suppl. material 1: Table S4, rels 10–12)

Single-species or species-poor pioneer helophytic community, which establishes after human disturbance, with a dominance of *Nasturtium officinale*, with *Veronica anagallis-aquatica* and ingressive species from *Molinio-Arrhenatheretea*.

This community, typical of sunny, quickly to slowly flowing, oligo- to eutrophic waters (Buchwald 1994), is distributed in small stands along the ditches that cross cultivated lands, in contact with *Helosciadietum nodiflori*, *Glycerietum notatae*, *Callitriche stagnalis* community, and *Veronica anagallis-aquatica* community.

In Italy, this community is widely spread (e.g. Barberis and Mariotti 1981; Canullo et al. 1988; Géhu and Biondi 1988; Corbetta and Pirone 1989; Baldoni and Biondi 1993;

Pedrotti 1995; Biondi et al. 1997; Pirone et al. 1997; Scoppola 1998; Bracco et al. 2000; Brullo et al. 2002; Prosser and Sarzo 2003; Tomasi and Caniglia 2004; Ceschin and Salerno 2008; Pedrotti 2008; Lastrucci et al. 2010b, 2012, 2016, 2017c).

HELOSCIADIETUM NODIFLORI Maire 1924 (group 4, Suppl. material 1: Table S4, rels 13–16)

Vegetation of ditches characterized by *Helosciadium nodiflorum* with elements of the *Glycerio-Sparganion* alliance and the *Nasturtio-Glycerietalia* order (*Nasturtium officinale*, *Veronica anagallis-aquatica*, *Berula erecta*, and *Glyceria notata*).

We found this community along a short stretch of a ditch at the Palude di Colfiorito, in contact with *Beruletum erectae* and *Nasturtietum officinalis*, where water was 50-60 cm deep.

The association is rather frequent in Italy (e.g. Pedrotti, 1967, 1995, 2008; Canullo et al. 1988; Baldoni and Biondi 1993; Buchwald 1994; Pirone et al. 1997; Brullo et al. 2001, 2002; Prosser and Sarzo 2003; Biondi and Bagella 2005; Sburlino et al. 2008; Mereu et al. 2010; Lastrucci et al. 2016).

ELEOCHARITETUM PALUSTRIS Savič 1926 (group 5, Suppl. material 1: Table S5)

Single-species or species-poor pioneer plant community, physiognomically characterized by *Eleocharis palustris* subsp. *palustris*, sometimes associated with species of the *Molinio-Arrhenatheretea* class, coming from the surrounding meadows. The community develops where the soil is subject to periodic cycles of submergence and emergence until the end of spring and can tolerate long periods of flooding, but it can also withstand periods with dry soil (Šumberová 2011a).

We found this association in small patches at the edge of Palude di Colfiorito, in contact with communities referred to *Phragmition communis* and *Bidention tripartitae* alliances.

This vegetation type is distributed in northern and central Italy (e.g. Pedrotti et al. 1992; Buchwald 1994; Mariotti 1995; Biondi et al. 1997; Venanzoni and Gigante 2000; Tomei et al. 2001; Landi et al. 2002; Angiolini et al. 2003; Lastrucci et al. 2007, 2010a,b, 2012, 2019b).

SCHOENOPLECTETUM LACUSTRIS Chouard 1924 (group 6, Suppl. material 1: Table S6, rels 1–11)

Community characterized by *Schoenoplectus lacustris*, mostly occurring in the outer vegetation belt of the Palude di Colfiorito, where it forms dense and extensive monospecific stands between *Phragmitetum*/*Phalaridetum* and open waters. Where the stands are less dense, other species of the *Phragmition communis* alliance and higher-rank syntaxa, including *Phragmites australis*, *Phalaris arundinacea*, and *Typha latifolia*, enter into the composition of this community.

The *Schoenoplectetum lacustris* is in close contact with other associations of the *Phragmition communis* alliance, especially in the Palude di Colfiorito, and sometimes occupies the whole section of unmanaged ditches.

The association is rather frequent across Italy in marshes, around lakes and along watercourses (Fascetti et al. 1989; Poldini 1989; Brullo et al. 1994; Iberite et al. 1995; Venanzoni and Gigante 2000; Merloni and Piccoli 2001; Landi et al. 2002; Venanzoni et al. 2003; Lastrucci et al. 2007; Ceschin and Salerno 2008; Lastrucci et al. 2019b).

IRIDETUM PSEUDACORI Eggler 1933 ex Brzeg et M. Wojterska 2001 (group 6, Suppl. material 1: Table S6, rels 12–15)

Plant community with a dominance of *Limniris pseudacorus*, with species of the *Phragmition communis* alliance (e.g. *Typha latifolia* and *Schoenoplectus lacustris*) and ingressive species from the *Molinio-Arrhenatheretea* class, coming from the surrounding meadows.

We found this association inside depressions in the humid meadows and along some ditches of the Piano di Colfiorito.

Limniris pseudacorus-dominated communities had been found in various Italian wetlands from the Trentino-Alto Adige to Sicily (e.g. Brullo et al. 1994; Pedrotti 1995; Pirone et al. 1997; Raimondo et al. 2000; Arrigoni and Papini 2003; Prosser and Sarzo 2003; Maiorca et al. 2005; Presti et al. 2005; Ceschin and Salerno 2008; Lastrucci et al. 2010a,b, 2016).

TYPHETUM LATIFOLIAE Nowiński 1930 (group 6, Suppl. material 1: Table S6, rels 16–20)

Species-poor plant community, characterized by *Typha latifolia*, associated with other species of the *Phragmition communis* alliance (*Schoenoplectus lacustris* and *Glyceria maxima*).

Typhetum latifoliae occurs in stagnant or slowly flowing waters of marshes and ditches, less than 50 cm deep, in contact with other associations of *Phragmito-Magnocaricetea* and, to the inside of the basins and ditches, with the hydrophytic coenoses of *Potamogetonetea*.

It is very common in Italian wetlands (e.g. Martini and Poldini 1980; Corbetta and Pirone 1989; Baldoni and Biondi 1993; Biondi and Baldoni 1994; Buchwald 1994; Biondi et al. 1997; Bracco et al. 2000; Venanzoni and Gigante 2000; Viciani and Raffaelli 2003; Prosser and Sarzo 2004; Ceschin and Salerno 2008; Lastrucci et al. 2010a,b, 2012).

CAREX HIRTA community (group 6, Suppl. material 1: Table S6, rels 21–23)

Species-poor plant community, with a dominance of *Carex hirta*. Due to the occurrence of elements of *Potentillion anserinae* and higher-rank syntaxa, we placed this community in the *Potentillion anserinae* alliance, even though the presence of some elements of the *Phragmito-Magnocaricetea* class marks its transition towards the coenoses of flooded habitats. Because of the lack of floristic characterization, we could not classify it at the association level.

Toward the inside of the basins, this community is in contact with helophytic communities of *Phragmition communis* and *Magnocaricion gracilis*, and toward the external areas, with *Ranunculion velutini* meadows.

In Tuscany, Lastrucci et al. (2019b) found a community characterized by *Carex hirta* and *C. otrubae*, in fresh, partially shaded and not submerged soils. Biondi and Ballelli (1995) described in Umbria a *Carex hirta*-dominated association, the *Ranunculo acri-Caricetum hirtae*, which was found by Ciaschetti et al. (2020) in the highlands of Abruzzo. However, in our opinion there are not enough elements to attribute this community to this association, because all the diagnostic species except *Carex hirta* are absent (*Carex leporina*, *Ranunculus acris*, *R. repens,* and *Alopecurus rendlei*).

GLYCERIETUM MAXIMAE Nowiński 1930 corr. Šumberová, Chytrý et Danihelka in Chytrý 2011 (group 6, Suppl. material 1: Table S6, rels 24–30)

Species-poor plant community of marshes and ditches, with a dominance of *Glyceria maxima*, which is associated with other species of the *Phragmition communis* alliance and higher syntaxa, including *Phragmites australis*, *Phalaris arundinacea*, *Alisma plantago-aquatica*, *Sparganium erectum*, and *Lycopus europaeus*.

The community forms more or less extensive stands in the outer part of the Palude di Colfiorito basin, where, according to Pedrotti and Murrja (2020) is reducing its extent, and in small parts of some ditches in other plains, in contact with the associations of the *Phragmition communis* and *Glycerio-Sparganion* alliances.

In Italy this vegetation type is reported from lowland to submontane areas of northern and central Italy (e.g. Pedrotti 1965; Gerdol et al. 1979; Arrigoni and Ricceri 1982; Piccoli and Gerdol 1982; Marchiori and Sburlino 1986; Pedrotti 1995; Sartori and Bracco 1997; Catorci and Orsomando 2001; Lastrucci et al. 2010b, 2014).

CARICETUM VESICARIAE Chouard 1924 (group 7, Suppl. material 1: Table S7)

Species-poor, sometimes monospecific helophytic community, dominated by *Carex vesicaria*, belonging to the *Magnocaricion gracilis* alliance, with a few other species of *Phragmito-Magnocaricetea* class (e.g. *Typha latifolia*, *Glyceria notata*, and *Rorippa amphibia*), typical of stagnant waters and marshy meadows, which grows on meso-eutrophic, mineral or semi-peaty soils (Mierwald 1988).

The association is uncommon in the study area and occurs along a short stretch of the main ditch of the Piano di Arvello.

The association had been found in wetlands of northern and central Italy (Cortini Pedrotti et al. 1973; Martini and Poldini 1980; Montanari and Guido 1980; Pirone 1987; Marchiori et al. 1993; Buchwald 1994; Gerdol and Tomaselli 1997; Marchiori and Sburlino 1997; Rossi and Alessandrini 1998; Prosser and Sarzo 2003; Lastrucci et. al. 2008).

CARICI OTRUBAE-JUNCETUM INFLEXI Minissale et Spampinato 1985 (group 8, Suppl. material 1: Table S8)

Species-poor sub-nitrophilous and sub-hygrophilous community dominated by *Juncus inflexus* subsp. *inflexus*, associated with species of the *Potentillo-Polygonetalia* order and *Molinio-Arrhenateretea* class, e.g. *Carex otrubae*, *Ranunculus repens*, *Carex hirta*, *Galium album* subsp. *album*, and *Rumex acetosa*. The species composition of the community allows us to place it in the *Potentillo-Polygonetalia* order of the *Molinio-Arrhenateretea* class. This is consistent with Landucci et al. (2020), who excluded *Juncus inflexus* communities from the *Phragmito-Magnocaricetea* vegetation in Europe.

The species composition of this community differs from that of *Galio palustris-Juncetum inflexi*, described by Venanzoni and Gigante (2000), because of the absence of *Galium palustre* and *Scutellaria galericulata* and the prevalence of species of the *Molinio-Arrhenatheretea* class. It also differs from the *Mentho longifoliae-Juncetum inflexi* Lohmeyer ex Oberdorfer 1957 asssociation because *Mentha longifolia*, characteristic of the association, is absent. Because of the dominance of the helophyte *Juncus inflexus* subsp. *inflexus* and the presence of *Carex otrubae*, we attributed this community to the *Carici otrubae-Juncetum inflexi*, described at Lake Gurrida in northeastern Sicily by Minissale and Spampinato (1985) and found in Calabria (Maiorca et al. 2005) and Tuscany (Lastrucci et al. 2019b).

The association is in contact with some communities of *Phragmition communis*, i.e. *Phalaridetum arundinaceae*, *Schoenoplectetum lacustris*, *Glycerietum maximae*, and with the humid meadows of the *Ranunculion velutini* alliance. The other contact vegetation is the *Carex otrubae* community, toward the banks of some ditches subjected to periodic desiccation.

URTICO DIOICAE-SAMBUCETUM EBULI (Br.-Bl. in Br.-Bl., Gajewski, Wraber et Wa1as 1936) Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 (group 9, Suppl. material 1: Table S9)

Thermo-heliophilous and nitrophilous association, characterized by *Sambucus ebulus*, with *Urtica dioica* and species of the *Balloto-Conion maculati* alliance and higher syntaxa, such as *Conium maculatum*, *Rubus caesius*, *Cruciata laevipes*, *Galium aparine*, and ingressive species from *Molinio-Arrhenatheretea*.

The association occurs sporadically on nitrogen-rich soils, at the edge of roads, paths, and hedges around the wetlands.

This association has been found in northern (Poldini 1980; Tomaselli et al. 2006), central (Biondi and Ballelli 1982; Lastrucci et al. 2010a,b, 2014), and southern Italy (Brullo et al. 1998; Maiorca and Spampinato 1999).

CARICETUM RIPARIAE Máthé et Kovács 1959 (group 10, Suppl. material 1: Table S10, rels 1–3)

Species-poor *Carex riparia*-dominated community, with a low number of *Phragmito-Magnocaricetea* species and ingressive elements from the *Molinio-Arrhenatheretea* class. The occurrence of *C. acuta* and *C. vesicaria*, besides the dominant species, allows its attribution to the community of the *Caricetum ripariae* association, included in the *Magnocaricion gracilis* alliance, following Landucci et al. (2020).

This community is very fragmented and forms dense stands in marshy meadows and ditches, in contact with the communities of the *Phragmition communis* and *Magnocaricion gracilis* alliances.

This association is rather frequent, but endangered, across the Italian Peninsula (e.g. Anoè and Caniglia 1987; Orsomando 1993; Pirone et al. 1997; Sartori and Bracco 1997; Prosser and Sarzo 2004; Landucci et al. 2013; Lastrucci et al. 2014, 2016) and Sicily (Brullo et al. 1998, 2002).

CYPERETUM LONGI (Micevski 1957) Micevski 1963 (group 10, Suppl. material 1: Table S10, rels 4–5)

Community characterized by *Cyperus longus*, poor in elements of the *Phragmito-Magnocaricetea* class, with several ingressive species from *Molinio-Arrhenatheretea*.

Because of the dominance of *Cyperus longus* and the presence of species of the *Phragmito-Magnocaricetea* and *Molinio-Arrhenatheretea* classes, following Landucci et al. (2020), this plant community fits with the *Cyperetum longi* association (*Phragmition communis* alliance).

This community is uncommon in the study area, where it forms small and dense stands, in periodically flooded soils, in contact with *Phragmitetum australis* and the communities of the *Ranunculion velutini* alliance.

In Italy, the association was found in Tuscany (Lastrucci et al. 2010a,b, 2016), Umbria (Venanzoni and Gigante 2000; Pedrotti 2008; Lastrucci et al. 2012), Abruzzo (Corbetta and Pirone 1989; Pirone et al. 2003), Molise (Paura et al. 2004), Basilicata (Venanzoni et al. 2003), and Sicily (Brullo et al. 1994).

PHRAGMITETUM AUSTRALIS Savič 1926 (group 10, Suppl. material 1: Table S10, rels 6–21)

Helophytic single-species or species-poor community, dominated by *Phragmites australis*, attributed to the *Phragmitetum australis* association, including species of the *Phragmition communis* alliance and higher syntaxa, as well as ingressive elements from the *Molinio-Arrhenatheretea* and *Artemisietea vulgaris* classes.

It is the dominant type of vegetation in the Palude di Colfiorito, where it develops in stagnant eutrophic waters with ground flooded from autumn to early summer and not drying in summer. In the other plains, this association occurs in the bed of the ditches.

If it is not subjected to periodic disturbance (mowing or tillage), this community tends to colonize the marshy and humid meadows in the outer vegetation band of the Palude di Colfiorito and the uncultivated lands in contact with the wetland vegetation (Catorci et al. 2010). Lastrucci et al. (2019a) documented the increasing fragmentation related to the dieback process of the reed bed along the waterfront and the expansion of the reeds in terrestrial habitats formerly occupied by different types of natural vegetation. *Phragmites australis* is in fact a highly competitive species, which can invade other plant communities in the absence of disturbance. This colonization process was observed for the *Carex panicea* peaty meadow community, which once had spread over a large area in the south-western part of the Palude di Colfiorito (Pedrotti 1975) and has disappeared as a consequence of competition with *Phragmites australis*. In fact, relevés carried out in the area formerly occupied by the *C. panicea* community (Pedrotti 2019), with very rare and interesting species from a biogeographical and conservation viewpoint, such as *Dactylorhiza incarnata* and *Epipactis palustris*, were grouped by the cluster analysis among those of *Phragmitetum australis*, indicating a dynamic stage of vegetation. Nowadays, this area is almost completely invaded by shrubs (Pedrotti 2019).

To the inside of the basin, the community is in contact with the hydrophytic communities of the *Nymphaeion* alliance, while to the outside of the basin, it is in contact with other *Phragmito-Magnocaricetea* and *Molinio-Arrhenatheretea* communities, with which it sometimes forms compenetrations.

The association is very common in all the countries of the temperate zone, including Italy (e.g. Corbetta and Pirone 1989; Baldoni and Biondi 1993; Buchwald 1994; Iberite et al. 1995; Pirone et al. 1997; Venanzoni and Gigante 2000; Arrigoni and Papini 2003; Ceschin and Salerno 2008; Lastrucci et al. 2010a,b, 2012, 2017c, 2019b). In particular, in the Palude di Fucecchio, Lake Chiusi (Tuscany), Lake Vico (Latium), Lake Trasimeno, and Palude di Colfiorito (Umbria), Lastrucci et al. (2017a) described seven variants, four of which (with *Myriophyllum spicatum*, *Schoenoplectus lacustris*, *Calystegia sepium*, and *Urtica dioica*) were found at the Palude di Colfiorito.

POLYGONO LAPATHIFOLII-XANTHIETUM ITALICI Pirola et Rossetti 1974 (group 11, Suppl. material 1: Table S11, rel. 1)

Therophytic ephemeral plant community, which appears in late-summer in temporarily flooded nutrient-rich and silty-sandy soils, characterised by species of the *Bidentetea tripartitae* class and ingressive elements from Stellarietea mediae and *Artemisietea vulgaris* classes. Because of the dominance of *Xanthium italicum* and the occurrence of *Persicaria lapathifolia*, we attributed it to the *Polygono lapathifolii-Xanthietum italici* association (*Chenopodion rubri* alliance).

The very fragmented stands of this association (sometimes extended a few square meters) occur on the external edge of humid meadows, in contact with croplands.

The association is known for the border of water basins on silty-sandy nitrophilous soils (Lastrucci and Becattini 2008; Sciandrello 2009), but it is more common along watercourses in northern Italy (Liguria, Lombardia, Emilia Romagna), central Italy, Molise, Sicily (e.g. Mariotti 1995; Assini 1997; Sartori and Bracco 1997; Biondi et al. 1997, 1999, 2004; Brullo et al. 2002; Paura et al. 2004; Ceschin and Salerno 2008; Lastrucci et al. 2010b; Crisanti and Taffetani 2015).

BIDENTETUM TRIPARTITAE Miljan 1933 (group 11, Suppl. material 1: Table S11, rels 2–5)

Therophytic ephemeral plant community of temporarily flooded, nutrient-rich areas, which appears in the late summer, characterized by the annual species *Bidens tripartita* subsp. *tripartita* and *Persicaria lapathifolia*, characteristic of the association *Bidentetum tripartitae* and higher syntaxa, and transgressive species from *Potentillion anserinae* alliance.

The very fragmented stands of this association, sometimes extended a few square meters, occur at the edge of marshy and humid meadows, which are flooded until late spring-early summer and emerge in mid-late summer.

Two variants of this association, characterized by *Persicaria lapathifolia* and *Chenopodiastrum murale* were found by Pedrotti and Murrja (2020) in the eastern part of the Palude di Colfiorito.

In Italy, it was found in northern and central Italy and Sicily (Martini and Poldini 1980; Marchiori et al. 1993; Biondi et al. 1999, 2003; Sarzo et al. 1999; Brullo et al. 2002; Pirone et al. 2003; Prosser and Sarzo 2004).

EPILOBIUM HIRSUTUM community (group 12, Suppl. material 1: Table S12, rel. 1)

Epilobium hirsutum-dominated nitrophilous community found at the edge of the humid meadows of *Ranunculion velutini*. Given that most of the species of this community are characteristic of *Potentillion anserinae* and higher syntaxa, e.g. *Ranunculus repens*, *Galega officinalis*, and *Lotus corniculatus*, we placed it in the *Potentillion anserinae* alliance.

GALEGA OFFICINALIS community (group 12, Suppl. material 1: Table S12, rels 2–7)

Nitrophilous pioneer community, physiognomically characterized by *Galega officinalis*, including species of the *Potentillion anserinae* alliance and higher syntaxa, e.g. *Ranunculus repens*, *Galium album* subsp. *album*, and *Poa trivialis*. The occurrence of ingressive species from the *Phragmito-Magnocaricetea*, *Stellarietea mediae*, and *Artemisietea vulgaris* classes indicates the placement of this community between the helophytic vegetation of *Phragmition communis* / *Magnocaricion gracilis* and anthropogenic vegetation.

This community occurs along the banks of ditches at the borders of the plains, periodically flooded during the year, with alternation of a flooding phase in winter and spring and a summer emergence phase.

Venanzoni and Gigante (2000) described in the Lakes Trasimeno and Alviano (Umbria) the *Cirsio triumfetti-Galegetum officinalis* association, placed in the *Potentillion anserinae* alliance. Compared to that association, our relevés lack *Cirsium creticum* subsp. *triumfettii*, *Convolvulus sepium*, and *Lotus tenuis*, characteristic species of this association. However, we did not find enough elements to describe a new association.

Pedrotti and Murrja (2020) found a similar community in the eastern part of the Palude di Colfiorito and referred it to the *Cirsio triumfetti-Galegetum officinalis* association; however, in our opinion, this attribution is doubtful because it lacks the characteristic species except *C. creticum* subsp. *triumfettii*.

DESCHAMPSIO-CARICETUM DISTANTIS Pedrotti 1976 (group 13, Suppl. material 1: Table S13)

Thick-sward wet meadows, dominated by *Deschampsia cespitosa*. The occurrence of *Ranunculus velutinus*, *Lolium arundinaceum* subsp. *arundinaceum*, *Orchis laxiflora*, *Bellevalia romana*, *Trifolium resupinatum*, and *Alopecurus rendlei* justifies placing the community in the *Ranunculion velutini* alliance and the *Trifolio-Hordeetalia* order. The occurrence of *Carex distans*, besides *Deschampsia cespitosa*, allows its attribution to the *Deschampsio-Caricetum distantis* association, described by Pedrotti (1976) in the nearby Piani di Montelago (Marche).

This community, found in depressions flooded until early summer and moist until the end of summer, is in contact with *Hordeo-Ranunculetum velutini* meadows, inside which it sometimes forms more or less extended patches, and with communities of the *Phragmitetalia* and *Nasturtio-Glycerietalia* orders.

The association is endemic of the humid meadows of central and southern Italy (Pedrotti 1975; 1976; Canullo et al. 1988; Pedrotti el al. 1992; Pirone 1997; Catorci and Orsomando 2001; Tardella et al. 2002).

HORDEO-RANUNCULETUM VELUTINI Pedrotti 1976 (group 14, Suppl. material 1: Table S14)

Community of humid hay meadows with a dense sward, common in areas that remain flooded until early spring, while the ground dries up in the early summer. It is physiognomically characterized by *Ranunculus velutinus*, *Cynosurus cristatus*, *Poa pratensis* subsp. *pratensis*, *Centaurea jacea* subsp. *jacea*, and *Trifolium pratense*. The occurrence of *Lolium arundinaceum* subsp. *arundinaceum*, *Orchis laxiflora*, and *Gaudinia fragilis*, besides *Ranunculus velutinus*, justify placing the community in the *Ranunculion velutini* alliance and the *Trifolio-Hordeetalia* order, while the presence of *Hordeum secalinum*, *Bromus racemosus* subsp. *racemosus*, *Trifolium dubium*, *T. resupinatum*, *Alopecurus rendlei*, and *Bellevalia romana* indicates that the community fits with the association *Hordeo-Ranunculetum velutini*.

This association is in contact with the helophytic associations of *Phragmito-Magnocaricetea* toward the inside of the basins, and with the therophytic nitrophilous communities, and croplands, toward the outside.

This association, described by Pedrotti (1976) in the nearby Piani di Montelago (Marche), is endemic to the central and southern Apennines (Pedrotti 1967, 1975; Canullo et al. 1988; Pedrotti et al. 1992; Venanzoni 1992; Catorci and Orsomando 2001; Tardella et al. 2002).

SPARGANIETUM ERECTI Roll 1938 (group 15, Suppl. material 1: Table S15)

Plant community dominated by *Sparganium erectum*, which forms more or less thick stands. The dominant species and the presence of elements of the *Glycerio-Sparganion* alliance led us to attribute this community, following Venanzoni and Gigante (2000), Lastrucci et al. (2010b), and Pedrotti (2019), to the *Sparganietum erecti* association.

We found the plant community in stagnant waters, 10-50 cm deep, in contact with *Phragmitetum australis* and *Glycerietum maximae*.

It has been reported in northern, central, and southern Italy (e.g. Marchiori and Sburlino 1986, 1997; Corbetta and Pirone 1990; Baldoni and Biondi 1993; Buchwald 1994, Pedrotti 1995; Brullo et al. 1998; Venanzoni and Gigante 2000; Prosser and Sarzo 2003; Venanzoni et al. 2003; Ceschin and Salerno 2008; Lastrucci et al. 2010b, 2012, 2016, 2017c).

CARICETUM GRACILIS Savič 1926 (group 16, Suppl. material 1: Table S16)

Species-poor helophytic association, characterized by *Carex acuta*, which forms thick stands, with species of the *Magnocaricion gracilis* alliance and higher syntaxa (*Carex vesicaria*, *Galium palustre* subsp. *elongatum*, *Phalaris arundinacea*, etc.) and sporadic occurrences of ingressive species of the *Potentillo-Polygonetalia* and *Trifolio-Hordeetalia* orders (*Molinio-Arrhenatheretea* class).

The association occurs where the soil is frequently flooded from autumn to spring and remains muddy during summer, often in contact with other communities of the *Phragmito-Magnocaricetea* class.

This community is more frequent in northern Italy, but is recorded from several localities across the Italian peninsula (e.g. Cortini Pedrotti et al. 1973; Martini and Poldini 1980; Marchiori and Sburlino 1986; Marchiori et al. 1993; Venanzoni 1988; Buffa et al. 1995; Pirone and Tammaro 1995; Marchiori and Sburlino 1997; Sartori and Bracco 1997; Bracco et al. 2000; Prosser and Sarzo 2003).

POTENTILLA REPTANS community (group 17, Suppl. material 1: Table S17)

Species-poor hygro-nitrophilous plant community, dominated by *Potentilla reptans*.

The prevalence of floristic elements of *Potentillion anserinae* and higher syntaxa (*Potentilla reptans*, *Rumex crispus*, *Oenanthe fistulosa*, and *Thalictrum lucidum*) led us to place this community in the *Potentillion anserinae* alliance.

This community differs in species composition from *Rorippo amphibiae-Potentilletum reptantis* described in Valdichiana (Tuscany, Italy) by Lastrucci et al. (2010a), because of the absence of *Rorippa amphibia*, *R. prostrata*, *Bolboschoenus maritimus*, and *Oenanthe silaifolia*; however, there are no elements to describe a new association.

The *Potentilla reptans* community is generally present on the bottom of the sinkholes, in contact with *Phalaris arundinacea* and *Carex acuta*-dominated stands.

PHALARIDETUM ARUNDINACEAE Libbert 1931
TYPICUM (group 18, Suppl. material 1: Table S18, rels 1–15; *holotypus* Table 1, rel. 2 in Libbert 1931)
ALOPECURETOSUM BULBOSI subass. nova (group 18, Suppl. material 1: Table S18, rels 16–31, *holotypus* relevé 30)
CAREX ACUTA VARIANT (group 18, Suppl. material 1: Table S18, rels 16–24)

Helophytic association dominated by *Phalaris arundinacea*, with other species of *Phragmito-Magnocaricetea* (e.g. *Phragmites australis*, *Scutellaria galericulata*, *Eleocharis palustris*, *Lythrum salicaria*, and *Carex acuta*) and ingressive species from *Molinio-Arrhenatheretea* (e.g. *Lolium arundinaceum* subsp. *arundinaceum*, *Centaurea jacea* subsp. *jacea*, and *Trifolium pratense*). The species composition allows us to place this community in the *Phragmition communis* alliance (*Phragmitetalia* order, *Phragmito-Magnocaricetea* class), following Landucci et al. (2020).

The association is rather frequent across the Italian peninsula (e.g. Bracco 1981; Marchiori et al. 1993; Buchwald 1994; Venanzoni and Gigante 2000; Arrigoni and Papini 2003; Prosser and Sarzo 2003; Tomasi and Caniglia 2004; Lastrucci et al. 2007, 2010a,b, 2014; Ceschin and Salerno 2008).

The typical form of this community was found in sites with stagnant eutrophic waters, at the edge of ditches and swallow holes, characterized by seasonal fluctuations, in contact with other helophyitic coenoses of *Phragmito-Magnocaricetea* to the inside of the basin and the main ditches, and with wet meadows of *Trifolio-Hordeetalia*, hygro-nitrophilous communities and croplands to the outside.

In the areas where water is drained more rapidly by larger canals to foster the mowing of the surrounding hay meadows, and the soil remains waterlogged and humid for a shorter period, the species composition of the community changes, increasing species from the *Molinio-Arrhenatheretea* class. The occurrence of this group of species indicates the transition from *Phalaridetum arundinaceae* to humid meadows of *Ranunculion velutini* and allows us to describe the new subassociation *Phalaridetum arundinaceae alopecuretosum bulbosi*, whose differential species are *Alopecurus bulbosus* subsp. *bulbosus*, *A. rendlei*, *Oenanthe fistulosa*, *Trifolium resupinatum*, *Centaurea jacea* subsp. *jacea*, *Galium debile*, and *Plantago lanceolata*.

In small depressions of few centimeters or in contact with marsh vegetation of the *Magnocaricion gracilis*, where water stands for more time during the year, *Carex acuta* tends to become codominant with *Phalaris arundinacea*. We attributed this aspect to a *Carex acuta* variant of the subassociation *Phalaridetum arundinaceae alopecuretosum bulbosi*.

CAREX OTRUBAE community (group 19, Suppl. material 1: Table S19, rels 1–5)

Species-poor plant community of the stagnant waters dominated by *Carex otrubae*, present exclusively along the banks of ditches of modest depth, which during the year undergo periods of submergence (winter-early spring) and emergence (summer), depending on the variability of the water supply resulting from rainfall.

Carex otrubae communities found by Venanzoni and Gigante (2000) at Lakes Trasimeno and Alviano (Umbria), Minissale and Spampinato (1995) and Brullo et al. (2002) in Sicily, by Cortini Pedrotti et al. (1973) and Pedrotti (1982a) at the Pian Grande of Castelluccio di Norcia (Umbria), attributed to *Cypero longi-Caricetum otrubae* or *Caricetum otrubae*, were placed in the *Magnocaricion elatae* alliance, while Buchwald (1994) placed the *Carex otrubae* coenoses found at Pian Grande and Pian Piccolo (Sibillini Mountains, Umbria) in the *Potentillion anserinae* alliance; instead, Lastrucci et al. (2014) attributed the *C. otrubae* community found at Lake Montepulciano to the *Cypero longi-Caricetum otrubae* association, in the *Mentho-Juncion inflexi*. Because of the absence of species of *Magnocaricion elatae*, and the prevalence of floristic entities of *Potentillion anserinae* and higher syntaxa (*Ranunculus repens*, *Gratiola officinalis*, *Carex hirta*, and *Galium album* subsp. *album*), we considered it more appropriate to place this plant community in the *Potentillion anserinae* alliance.

The *Carex otrubae* community is in contact, toward the center of the ditch section, with the *Oenantho aquaticae-Rorippetum amphibiae*, *Carici otrubae-Juncetum inflexi*, *Glycerietum notatae*, and *Caricetum vesicariae* associations, while toward the external areas, it is in contact with the humid meadows of the *Ranunculion velutini*.

GRATIOLA OFFICINALIS community (group 19, Suppl. material 1: Table S19, rels 6-11)

Community characterized by *Gratiola officinalis*, which colonizes soils undergoing alternation of spring floods and summer desiccation, with species from peaty and marshy meadows, such as *Carex panicea*, *Dactylorhiza incarnata*, *Ranunculus flammula*, and *Oenanthe fistulosa*, and elements of *Potentillo-Polygonetalia*, such as *Mentha pulegium* subsp. *pulegium*, *Carex hirta*, *C. otrubae*, *Ranunculus repens*, and *Galium album* subsp. *album*.

We found this community inside depressions 20-30 cm deep, surrounded by the humid meadows of *Ranunculion velutini* alliance.

Two associations physiognomically characterized by *Gratiola officinalis* have been identified in Hungary (*Ranunculo flammulae-Gratioletum* Borhidi and Juhász 1985 of the *Eleocharition acicularis* alliance, see Borhidi and Juhász 1985), the Czech Republic and Slovakia (*Lathyro palustris-Gratioletum* Balátová-Tuláčková 1966 of the *Deschampsion cespitosae* alliance, Botta-Dukát et al. 2005). In Italy, Pedrotti (1982b) referred the occurrence of a community characterized by *Gratiola officinalis*, *Juncus inflexus*, and *Mentha pulegium* in 20-40 cm deep depressions in the basin of Lake Trasimeno, however without phytosociological relevés. Biondi and Bagella (2005) described the *Alismo lanceolatae-Gratioletum officinalis* association (*Glycerio-Sparganion*) in Sardinia, and the same association was found by Gigante et al. (2013) on the western side of Lake Trasimeno (Umbria). Lastrucci and Becattini (2008) found in temporarily flooded meadows near "Bosco ai Frati" (Tuscany) a *Gratiola officinalis* community, attributed to the *Molinio-Arrhenatheretea* class.

Because of the different floristic composition and biogeographic contexts, the abovementioned syntaxa do not seem suitable for interpreting the analyzed community; however, there are no elements to describe a new association. Given the high frequencies of species of *Potentillion anserinae* and the higher syntaxonomic units, we propose placing this community in the *Potentillion anserinae* alliance.

OENANTHO AQUATICAE-RORIPPETUM AMPHIBIAE Lohmeyer 1950 (group 19, Suppl. material 1: Table S19, rel. 12-15)

Plant community physiognomically characterized by *Rorippa amphibia*, with *Mentha aquatica* subsp. *aquatica*, *Myosotis scorpioides* and other species of the *Phragmito-Magnocaricetea* class, such as *Phalaris arundinacea*, *Glyceria maxima*, *Alisma plantago-aquatica*, *Glyceria notata*, and *Typha latifolia*. Sometimes there are submerged hydrophytic rooting species, such as *Myriophyllum verticillatum*, *Ranunculus trichophyllus*, and *Callitriche stagnalis*. The occurrence of species such as *Gratiola officinalis*, *Ranunculus repens* and *Rumex conglomeratus* indicates an early dynamic stage of this community, which will probably lead to progressive terrestrialization, testified by the *Rorippa amphibia* community, extremely species-poor and mainly composed of nitrophilous and ruderal species, found at the border of the Palude di Colfiorito by Pedrotti and Murrja (2020).

We refer this community to the *Oenantho-Rorippetum* association and the *Eleocharito palustris-Sagittarion sagittifoliae* alliance, often published under the synonym name *Oenanthion aquaticae* Hejny 1948 (Baldoni and Biondi 1993; Biondi et al. 2003).

The plant community develops in stagnant or slowly flowing waters, less than 50 cm deep, in contact with communities of the *Phragmition communis* alliance. It is indicated in northern and central Italy (e.g. Pedrotti 1977; Baldoni and Biondi 1993; Marchiori et al. 1993; Biondi and Baldoni 1994; Marchiori and Sburlino 1997; Lastrucci et al. 2007; Pedrotti and Murrja 2020).

Changes in the occurrence of plant communities

In the relevés carried out in the period 1963-1977, Pedrotti reported 40 plant communities (Suppl. material 2: Table S20), 10 hydrophytic (*Charetea*, *Potamogetonetea*, and *Lemnetea* classes), 17 helophytic (*Phragmito-Magnocaricetea*), six humid meadow communities (*Molinio-Arrhenatheretea*), three communities of peat bogs (*Scheuchzerio-Caricetea nigrae*), two of temporarily flooded lands (*Bidentetea*), one of *Isoëto-Nanojuncetea*, and one of *Epilobietea angustifolii* (Pedrotti 1975, 2019) (Suppl. material 2: Table S20).

In our survey (years 2005-2009), we found 39 plant communities referred to the *Potamogetonetea* (six communities), *Bidentetea* (2), *Phragmito-Magnocaricetea* (21), *Molinio-Arrhenatheretea* (9), and *Epilobietea angustifolii* (1) classes. Twenty-two of them confirm the findings of Pedrotti (1975, 1976, 2019), Buchwald (1994), Orsomando (2000, 2002), and Tardella et al. (2002), while 17 were new records for the study area. Twenty-four communities, found by Pedrotti (1975, 2019), instead, were not confirmed (eight of *Charetea*, *Lemnetea minoris*, and *Potamogetonetea*, one of *Bidentetea*; seven of *Phragmito-Magnocaricetea*; three of *Scheuchzerio-Caricetea fuscae*, four of *Molinio-Arrhenatheretea* and one of *Isoëto-Nanojuncetea*).

Changes in the occurrence of the habitats of conservation interest

As far as habitats of community interest are concerned, 19 plant communities found by Pedrotti in the 1960s/1970s can be ascribed to seven habitats of community interest (Suppl. material 2: Table S20). Three of these habitats (3140 – Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.; 3170* – Mediterranean temporary ponds; and 7230 – Alkaline fens) have not been confirmed in our research. In particular, habitat 7230, related to the peat bog, has completely disappeared. In the early 2000s, there was still a residual area characterized by *Carex panicea*, *Epipactis palustris*, and *Dactylorhiza incarnata* (Tardella, pers. obs.), which was invaded by *Phragmites australis* in the subsequent years (see Suppl. material 1: Table S10, relevés 6–7) and, then, by shrubs (Pedrotti 2019). The habitats that can be confirmed, also in the light of the most recent available relevés are: 3150 – Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (two communities of the *Potamogetonion* and two of the *Nymphaeion* alliances); 3260 – Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (two communities of the *Ranunculion aquatilis*); 3270 – Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation (one community of the *Bidention tripartitae* and one of the *Chenopodion rubri*); and 6510 – Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) (two communities of the *Ranunculion velutini*).

Conclusions

We found a considerable richness in plant communities (39 vegetation units, belonging to five vegetation classes). Most of them are of high conservation interest in central Italy because they are endemic to the central and southern Apennines (meadows of the *Ranunculion velutini* alliance), rare or endangered in peninsular Italy (hydrophytic and helophytic vegetation of *Potamogetonetea* and *Phragmito-Magnocaricetea* classes), and deemed habitats of community interest according to the 92/43/EEC Directive. However, we did not confirm 24 plant communities found in the past, most of which can be attributed to habitats of community interest.

The studied wetland system underwent several alterations over time and is still threatened by the reduction of precipitation due to climate change, anthropic activities outside or bordering on the basins, such as tillage of croplands, circulation of agricultural vehicles, cropland fertilization that causes eutrophication of the water bodies, and unauthorized water collection for irrigation purposes. The lack or the discontinuity of management and maintenance interventions in part of the study area, especially the lack of management of the reed beds, canals, and ditches, could further negatively impact the biodiversity of the wetland system. The reed expansion to the outside of the basins, the increase in the extent of the *Nymphaeetum albae*, and the filling of small artificial watercourses is threatening rare species (e.g. *Ranunculus ophioglossifolius*, *R. flammula*, *Equisetum fluviatile*, and *Ophioglossum vulgatum*, see Ballelli et al. 2010) and fragmenting or substituting plant communities of small extent, such as some hydrophytic and therophytic communities. Moreover, these pressures are exacerbated by the absence of buffer zones covered by meadows between arable lands and wetlands.

To preserve plant species and vegetation diversity of these wetlands, besides the implementation of the usual maintenance activities (cleaning of ditches and mowing of the hay meadows), some conservation actions are advisable, such as the periodical mowing of the reed bed to contain its expansion outwards, and the removal of dead material from the bottom of water pools and canals. Finally, the monitoring of the species composition of plant communities, and of changes in the vegetation mosaic, periodically updating the vegetation maps, is of great importance for the management of the wetland system.

Syntaxonomic scheme

POTAMOGETONETEA Klika in Klika et Novák 1941
POTAMOGETONETALIA Koch 1926
Potamogetonion Libbert 1931
Potamogetono pectinati-Myriophylletum spicati Rivas Goday 1964
Myriophylletum verticillati Gaudet ex Šumberová in Chytrý 2011
Nymphaeion albae Oberd. 1957
Nymphaeetum albae Vollmar 1947
Persicaria amphibia community
Ranunculion aquatilis Passarge ex Theurillat in Theurillat et al. 2015
Potamogetono crispi-Ranunculetum trichophylli Imchenetzky 1926
Callitriche stagnalis community

BIDENTETEA Tüxen et al. ex von Rochow 1951
BIDENTETALIA Br.-Bl. et Tüxen ex Klika et Hadač 1944
Bidention tripartitae Nordhagen ex Klika et Hadač 1944

Bidentetum tripartitae Miljan 1933
Chenopodion rubri (Tüxen in Poli et J. Tüxen 1960) Hilbig et Jage 1972
Polygono lapathifolii-Xanthietum italici Pirola et Rossetti 1974

PHRAGMITO-MAGNOCARICETEA Klika in Klika et Novák 1941
PHRAGMITETALIA Koch 1926
Phragmition communis Koch 1926
Glycerietum maximae Nowiński 1930 corr. Šumberová, Chytrý et Danihelka in Chytrý 2011
Iridetum pseudacori Eggler 1933 ex Brzeg et M. Wojterska 2001
Phalaridetum arundinaceae Libbert 1931
typicum
alopecuretosum bulbosi subass. nova
alopecuretosum bulbosi subass. nova *Carex acuta* variant
Phragmitetum australis Savič 1926
Cyperetum longi (Micevski 1957) Micevski 1963
Schoenoplectetum lacustris Chouard 1924
Typhetum latifoliae Nowiński 1930
MAGNOCARICETALIA Pignatti 1953
Magnocaricion gracilis Géhu 1961
Caricetum gracilis Savič 1926
Caricetum ripariae Máthé et Kovács 1959
Caricetum vesicariae Chouard 1924
OENANTHETALIA AQUATICAE Hejný ex Bálatová-Tuláčková, Mucina, Ellmauer et Wallnöfer in Grabherr et Mucina 1993
Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964
Eleocharitetum palustris Savič 1926
Oenantho aquaticae-Rorippetum amphibiae Lohmeyer 1950
NASTURTIO-GLYCERIETALIA Pignatti 1953
Glycerio-Sparganion Br.-Bl. et Sissingh in Boer 1942
Beruletum erectae Roll 1938
Glycerietum notatae Kulczyński 1928
Rorippo ancipitis-Catabrosetum aquaticae (Oberdorfer 1957) Müller et Görs 1961
Helosciadietum nodiflori Maire 1924
Nasturtietum officinalis Gilli 1971
Sparganietum erecti Roll 1938
Veronica anagallis-aquatica subsp. *anagallis-aquatica* community

MOLINIO-ARRHENATHERETEA Tüxen 1937
TRIFOLIO-HORDEETALIA Horvatić 1963
Ranunculion velutini Pedrotti 1978
Deschampsio-Caricetum distantis Pedrotti 1976
Hordeo-Ranunculetum velutini Pedrotti 1976
POTENTILLO-POLYGONETALIA AVICULARIS Tüxen 1947
Potentillion anserinae Tüxen 1947
Carex hirta community
Carex otrubae community
Galega officinalis community
Gratiola officinalis community
Epilobium hirsutum community
Potentilla reptans community
Mentho longifoliae-Juncion inflexi T. Müller et Görs ex de Foucault 2009
Carici otrubae-Juncetum inflexi Minissale et Spampinato 1985

EPILOBIETEA ANGUSTIFOLII Tüxen et Preising ex von Rochow 1951
ARCTIO LAPPAE-ARTEMISIETALIA VULGARIS Dengler 2002
Balloto-Conion maculati S. Brullo et Marcenò 1985
Urtico dioicae-Sambucetum ebuli (Br.-Bl. in Br.-Bl., Gajewski, Wraber et Wa1as 1936) Br.-Bl. in Br.-Bl., Roussine et Nègre 1952

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Appendixes

Appendix I – Coordinates of localities.

Palude di Colfiorito: 43° 01.35' N; 12° 52.50' E
Piano di Annifo: 43° 02.50' N; 12° 52.20' E
Piano di Arvello: 43° 02.15' N; 12° 51.20' E
Piano di Colfiorito: 43° 02.30' N; 12° 54.60' E
Piano di Colle Croce: 43° 03.70' N; 12° 51.95' E
Piano di Popola e Cesi: 43° 00.00' N; 12° 53.85' E
Piano di Ricciano: 43° 00.45' N; 12° 50.90' E

Appendix II – Dates of relevés.

Suppl. material 1: Table S1 – Rels 1–10: 12/08/2006.

Suppl. material 1: Table S2 – Rels 1–4: 20/05/2006; rels 5–6: 27/05/2006; rels 7–8: 18/05/2009.

Suppl. material 1: Table S3 – Rels 1, 3, 6–9: 27/05/2006; rels 2: 18/05/2009; rels 4–5: 17/05/2008.

Suppl. material 1: Table S4 – Rels 1–3: 18/05/2009; rel. 4: 24/05/2008; rels 5–6: 26/08/2006; rels 7–8: 20/05/2006; rels 9: 30/05/2009; rel. 10: 03/09/2005; rels 11: 20/05/2006; rel. 12: 30/05/2009; rels 13–16: 20/05/2006.

Suppl. material 1: Table S5 – Rel. 1: 20/05/2006; rels 2: 27/05/2006; rels 3–4: 02/06/2005.

Suppl. material 1: Table S6 – Rels 1–2, 3, 9, 16, 19–20: 27/05/2006; rels 4, 5: 20/05/2006; rels 6–7, 27: 11/07/2005; rels 8, 18, 28: 03/09/2005; rels 10–15, 17, 29–30: 18/05/2009; rels 21: 27/05/2006; rels 22–23 02/06/2005; rels 24: 12/08/2006; rels 25–26: 21/06/2005.

Suppl. material 1: Table S7 – Rels 1–3: 27/05/2006.

Suppl. material 1: Table S8 – Rel. 1: 24/05/2008; rels 2, 8: 20/05/2006; rels 3–6, 9–11: 27/05/2006; rel. 7: 02/06/2005.

Suppl. material 1: Table S9 – Rels 1–2: 27/05/2006; rel. 3: 12/08/2006; rel. 4: 06/05/2006.

Suppl. material 1: Table S10 – Rels 1, 12–14: 27/05/2006; rels 2–3: 20/05/2006; Rel. 4–5: 26/08/2006; rels 6–7, 10–11, 15, 17–21: 03/09/2005; rels 8: 27/05/2006; rels 9, 11, 16: 18/05/2009.

Suppl. material 1: Table S11 – Rels 1–3, 5: 26/08/2006; rel. 4: 12/08/2006.

Suppl. material 1: Table S12 – Rels 1, 5: 26/08/2006; rels 2–3: 27/05/2006; rels 4, 7: 12/08/2006; rel. 6: 11/07/2005.

Suppl. material 1: Table S13 – Rel. 1: 24/05/2008;Rel. 2–3, 5: 10/06/2006; Rel. 4: 13/05/2006; Rel. 6–7, 7: 27/05/2006.

Suppl. material 1: Table S14 – Rels 1, 29–30, 34–37: 27/05/2006; rels 2–5: 24/06/2006; rels 6, 14–15: 24/05/2008; rels 7–8: 27/05/2006; rels 9–10: 20/05/2006;

rels 11, 16–17, 31, 33: 10/06/2006; rels 12–13, 20, 26: 18/05/2009; rels 21, 32: 02/06/2005; rels 22–23: 13/05/2006; rels 24–25: 20/05/2006; rels 27–28: 17/05/2008; rels 18–19: 31/05/2009.

Suppl. material 1: Table S15 – Rels 1–4: 11/07/2005.

Suppl. material 1: Table S16 – Rels 1, 6–7: 10/06/2006; rels 2: 10/06/2006; rels 3, 5, 11: 27/05/2006; rels 4, 12: 20/05/2006; rels 8–10: 02/06/2005; rels 13: 02/07/2005; rels14–15: 13/05/2006.

Suppl. materiale 1: Table S17 – Rel. 1: 27/05/2006; rel. 2: 10/06/2006.

Suppl. material 1: Table S18 – Rels 1–2: 20/05/2006; rels 3, 7–9, 19, 26–28: 27/05/2006; rels 4–5: 10/06/2006; rel. 6: 03/09/2005; rels 10, 18: 27/05/2006; rels 11–15: 11/07/2005; rels 16, 20–24, 31: 10/06/2006; rel. 25: 10/06/2006; rels 17, 29: 21/05/2005; rel. 30: 06/05/2006.

Suppl. material 1: Table S19 – Rels 1–5, 8–14: 27/05/2006; rel. 6: 13/05/2006; rel. 7: 13/05/2007; rel. 15: 24/05/2008.

Supplementary material 1

Tables S1–S19

Authors: Federico Maria Tardella, Vincenzo Maria Di Agostino

Data type: phytosociological tables

Explanation note: Phytosociological tables (Tables S1–S19) of the surveyed plant communities.

Link: https://doi.org/10.3897/PlantSociology.57.58883.suppl1

Supplementary material 2

Table S20

Authors: Federico Maria Tardella, Vincenzo Maria Di Agostino

Data type: data table

Explanation note: List of the plant communities found in the current research and of those found by other authors in the past.

Link: https://doi.org/10.3897/PlantSociology.57.58883.suppl2

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PENSOFT.

Società Italiana di Scienza della Vegetazione (SISV)

New national and regional Annex I Habitat records: from #16 to #20

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Abstract

New data on the distribution of the Annex I Habitats 3120, 3260, 6310, 9180* and 92A0 are reported in this contribution. In detail, 3 new occurrences in Natura 2000 Sites are presented and 5 new cells in the EEA 10 km x 10 km Reference grid are added. The new data refer to Italy and in particular to the Administrative Regions of Liguria, Sardinia, Sicily and Umbria. This issue of the section "Habitat records" includes an *Errata corrige* referring to the last released issue.

Keywords

3120, 3260, 6310, 9180*, 92A0, 92/43/EEC Directive, biodiversity, conservation, Italy, vegetation

Introduction

This is the fourth standardized contribution reporting records of new occurrences of Annex I Habitats in Europe. The occurrences reported here turned out to be new based on the comparison with the results of the 4th Report ex-Art. 17 on Annex I Habitat Monitoring in Europe (Eionet 2019). Also in this case, the related phytosociological relevés will be archived in the Italian database "VegItaly" (Gigante et al. 2012; Landucci et al. 2012).

Habitats Records

Data, details and descriptions of the new habitat records are hereafter provided, according to the standard format (Gigante et al. 2019). A general overview is reported in Tab. 1. For the cartographic analyses and maps production, the open source QGIS Geographic Information System (QGIS.org 2020) has been used.

#16. Annex I Habitat: 3120 Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean with *Isoëtes* spp. (Rivieccio G, Caria MC, Bagella S)

EUNIS Classification system: C3.42 Mediterraneo-Atlantic amphibious communities
Biogeographical Region: Mediterranean
National Habitat Checklist of reference: Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE (Biondi et al. 2009).

Table 1. Synthetic overview of the newly reported data.

Hab ID	Hab name	Cell ID	Country	BR	N2000 Site	Authors
3120	Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean with *Isoëtes* spp.	10kmE421N184	Italy	MED		Rivieccio G, Caria MC, Bagella S
3260	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.	10kmE457N219	Italy	CON	IT5210071	Bonini F
6310	Dehesas with evergreen *Quercus* spp.	10kmE471N167	Italy	MED	ITA030043	Gianguzzi L, Bazan G
9180*	*Tilio-Acerion* forests of slopes, screes and ravines.	10kmE414N232	Italy	MED		Dagnino D, Mariotti M
92A0	*Salix alba* and *Populus alba* galleries.	10kmE426N236	Italy	MED	IT1332717	Dagnino D, Turcato C

Phytosociological reference: *Helosciadio crassipedis-Isoëtetum tiguliannae* Biondi & Bagella 2005 nom. corr., *Helosciadienion crassipedis* Bagella, Caria, Farris & Filigheddu 2009 nom. corr., *Preslion cervinae* Br.-Bl. ex Moor 1937, *Isoëtetalia* Br.-Bl. 1936, *Isoëto-Nanojuncetea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946 (Bagella et al. 2009).
Geographic information: Italy, Sardinia, Oristano, Mogoro, 127 m a.s.l., Coordinates: 39.651615 N, 8.776443 E (Tab. 2, Rel. 1); Coordinates: 39.651672 N, 8.776348 E (Tab. 2, Rel. 2); Coordinates: 39.651818 N, 8.776509 E (Tab. 2, Rel. 3).
Cell ID in the EEA reference grid: 10kmE421N184 (Fig. 1).
Natura 2000 Site Code: currently not included in any Natura 2000 Site.
Phytosociological table: Tab. 2; taxonomic nomenclature according to Portale della Flora d'Italia (2019).
Notes: The association was described for the first time in the National Park "Arcipelago di La Maddalena" (Biondi and Bagella 2005) and referred later to the Tyrrhenian endemic suballiance *Apienion crassipedis* Bagella, Caria, Farris & Filigheddu 2009 (Bagella et al. 2009). The communities referred to this association should receive special attention for their chorological peculiarity, especially if located outside Natura 2000 network (Bagella et al. 2013).

#17. Annex I Habitat: 3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (Bonini F)

EUNIS Classification system: C2.2 Permanent non-tidal, fast, turbulent watercourses, C2.1 Springs, spring brooks and geysers [with the subtype C2.16 Crenal streams (spring brooks)]
Biogeographical Region: Continental
National Habitat Checklist of reference: Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE (Biondi et al. 2009).
Phytosociological reference: *Ranunculus trichophyllus*-dominated community (unpublished relevés: Tab. 3, Rel. 1; published relevés: Tab. 3, Rels 6 and 7 in Pedrotti 2008), *Veronico-Apietum submersi* Buchwald 1992 (unpublished relevés: Tab. 3, Rels 2 and 3; published relevés: Tab. 3, Rels. 1 to 5 in Pedrotti 2008), and *Callitrichetum obtusangulae* Seibert 1962 (published relevés: Tab. 2, Rels 1 and 2 in Pedrotti 2008), *Batrachion fluitantis* Neuhäusl 1959, *Callitricho hamulatae-Ranunculetalia aquatilis* Passarge ex Theurillat in Theurillat et al. 2015, *Potamogetonetea* Klika in Klika et Novák 1941 (Mucina 2016).
Geographic information: unpublished relevés: Italy, Umbria, Perugia, Norcia, Marcite, 564 m a.s.l., Coordinates: 42.793669 N, 13.083889 E (Tab. 3, Rel. 1); 563 m a.s.l., Coordinates: 42.792869 N, 13.082294 E (Tab. 3, Rel. 2); 563 m a.s.l., Coordinates: 42.792881 N, 13.082514 E (Tab. 3, Rel. 3); published relevés: Italy, Umbria, Perugia, Norcia, Marcite, 563 m a.s.l., Coordinates: unknown (Tab. 2, Rels 1 and 2 in Pedrotti 2008; Tab. 3, Rels 1 to 7 in Pedrotti 2008).
Cells ID in the EEA reference grid: 10kmE457N219 (Fig. 2).
Natura 2000 Site Code: SPA IT5210071 "Monti Sibillini (versante umbro)"
Phytosociological table: Tab. 3; published relevés: Tab. 2 (Rels 1 and 2) and Tab. 3 (Rels 1 to 7) in Pedrotti (2008); taxonomic nomenclature according to Bartolucci et al. (2018) and recent updatings (Portale della Flora d'Italia 2019).
Notes: The recorded communities occur in the area of the 'Marcite di Norcia' which is part of the SPA IT5210071 "Monti Sibillini (versante umbro)" as well as of the "Monti Sibillini" National Park.

The Habitat 3260 was already known for this SPA, with reference to another area (Fosso Mergani in Pian Grande of Castelluccio) falling in a different EEA cell (Eionet 2019). As concerns the new record, the *Ranunculus thrichophyllus*-dominated community occurs in the river Sordo bed, while the *Veronico-Apietum submersi* on a tributary southernmost spring stream. Surveys from this area had already been published by Pedrotti (2008) with no reference to Annex I habitats.

Although Habitat 3260 is reported in the Standard Data Form of the adjacent and contiguous SAC IT5210059 "Marcite di Norcia", falling in the same cell grid, it results as non-occurring in the 4th Report ex-Art. 17 on Annex I Habitat Monitoring (Eionet 2019). It should also be noticed that, due to recent changes, the current configura-

Table 2. Habitat 3120.

Relevé number	1	2	3	
Cell ID	10kmE421N184	10kmE421N184	10kmE421N184	
Latitude	39.651615	39.651672	39.651818	
Longitude	8.776443	8.776348	8.776509	
Date	5/21/2020	5/21/2020	5/21/2020	
Area (m²)	1	1	1	
Altitude (m a.s.l.)	127	127	127	
Cover (%)	90	70	60	
Average vegetation height (m)	0.5	0.5	0.6	
Water depth (cm)	0	0	0	Presences
Charact. and diff. taxa of the ass. and the upper units				
^ *Helosciadium crassipes* W.D.J. Koch ex Rchb.	4	3	3	3
^ *Isoëtes tiguliana* Gennari	2	.	2	2
Ranunculus ophioglossifolius Vill.	1	+	.	2
Illecebrum verticillatum L.	+	.	+	2
Oenanthe fistulosa L.	.	+	1	2
Other species				
Glyceria spicata Guss.	2	2	1	3
Eleocharis palustris (L.) Roem. & Schult.	2	1	1	3
Polypogon viridis (Gouan) Breistr.	1	.	+	2
Phalaris coerulescens Desf.	.	.	+	1
Agrostis pourretii Willd.	.	.	3	1

^ Reference plant species of the Habitat 3120, from Biondi et al. (2009).

Figure 1. Distribution in Italy of the Habitat 3120: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013-2018; Eionet 2019).

Table 3. Habitat 3260.

Relevé number	1	2	3	
Original relevé number	WF_38	WF_47	WF_48	
Cell ID	10kmE457N219	10kmE457N219	10kmE457N219	
Latitude	42.793669	42.792869	42.792881	
Longitude	13.083889	13.082294	13.082514	
Date	6/28/2018	7/3/2018	7/3/2018	
Area (m²)	4	4	4	
Altitude (m a.s.l.)	564	563	563	
Exposition (°)	-	-	-	
Slope (°)	0	0	0	
Cover (%)	90	95	80	Presences
Charact. and diff. taxa of *Batrachion fluitantis, Callitricho hamulatae-Ranunculetalia aquatilis, Potamogetonetea*				
^ *Helosciadium nodiflorum* (L.) W.D.J.Koch subsp. *nodiflorum* (fo.submersum)	.	5	4	2
^ *Ranunculus trichophyllus* Chaix	5	.	.	1
Other species				
^ *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica*	2m	+	.	2
^ *Nasturtium officinale* R.Br.	.	.	2b	1
Carex acutiformis Ehrh.	.	.	1	1
Glyceria notata Chevall.	.	.	1	1
Lemna minor L.	.	.	1	1
Mentha longifolia (L.) L.	.	1	.	1
Rumex conglomeratus Murray	.	1	.	1

^ Reference plant species of the Habitat 3260, from Biondi et al. (2009).

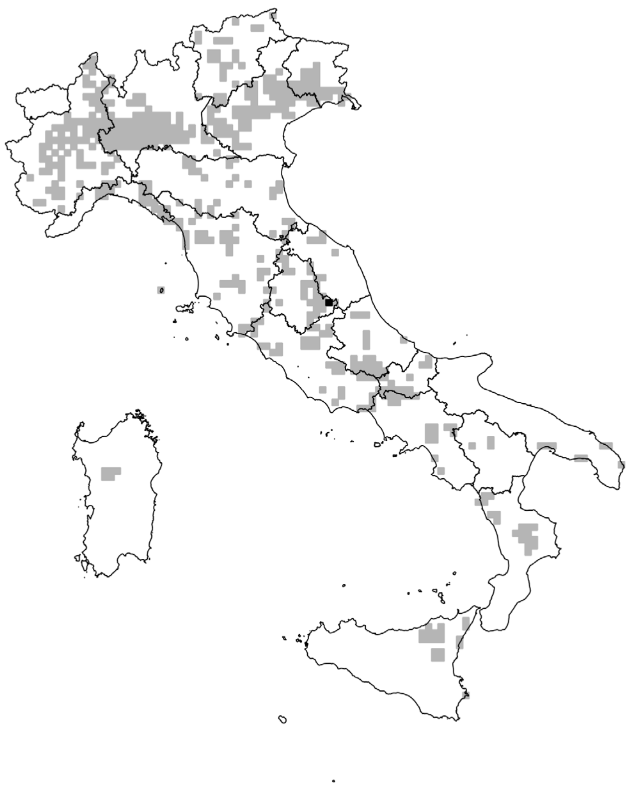

Figure 2. Distribution in Italy of the Habitat 3260: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013-2018; Eionet 2019).

tion of the SAC IT5210059 actually does not include the area of Marcite.

The alliance *Batrachion fluitantis* Neuhäusl 1959 (syn. *Ranunculion fluitantis* Neuhäusl 1959), originally used by Pedrotti (2008) for the syntaxonomic frame of the published relevés, has been recently referred to the order *Callitricho hamulatae-Ranunculetalia aquatilis* Passarge ex Theurillat in Theurillat et al. 2015, class *Potamogetonetea* Klika in Klika et Novák 1941 (Mucina et al. 2016).

#18. Annex I Habitat: 6310 Dehesas with evergreen *Quercus* spp. (Gianguzzi L, Bazan G)

EUNIS Classification system: E7.3 Dehesa
Biogeographical Region: Mediterranean
National Habitat Checklist of reference: Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE (Biondi et al. 2009).
Phytosociological reference: This habitat refers to a mosaic of plant communities, which can be framed in, or linked to, the following syntaxa: *Quercus suber* tree layer (*Genisto aristatae-Quercetum suberis* Brullo 1984, *pistacietosum lentisci* Brullo, Gianguzzi, La Mantia & Siracusa 2008), *Myrtus communis* hedgerow (*Erico arboreae-Myrtetum communis* Quezel, Barbero, Benabid, Loisel & Rivas-Martínez 1988, *calicotometum infestae* Brullo, Minissale, Signorello & Spampinato 1995), *Calicotome infesta* shrublands (*Pyro amygdaliformis-Calicotometum infestae* Gianguzzi & La Mantia 2008), *Cistus monspeliensis* formation (all. *Cisto-Ericion multiflorae* Horvatic 1958), *Hyparrhenia hirta* grassland (*Hyparrhenietum hirto-pubescentis* A.& O.Bolòs & Br.-Bl. in A. & O.Bolòs 1950), *Lolium perenne* and *Cynosurus cristatus* grassland (all. *Plantaginion cupanii* Brullo & Grillo 1978 , ord. *Cirsietalia vallis-demonii* Brullo & Grillo 1978, cl. *Molinio-Arrhenatheretea* Tüxen 1937), herb subnitrophilous vegetation of the *Echio-Galactition tomentosae* O. Bolòs & Molinier 1969 (Gianguzzi 2007; Brullo et al. 2008; Gianguzzi and La Mantia 2008).
Geographic information: Italy, Sicily, Caronia, Vallata Torrente Buzza (Contrada Porri Soprani), 140 m a.s.l., Coordinates: 38.02380 N, 14.49250 E (Tab. 4, Rel. 1); 38.02270 N, 14.49350 E (Tab. 5, Rel. 2).
Cells ID in the EEA reference grid: 10kmE471N167 (Fig. 3).
Natura 2000 Site Codes: SPA ITA030043 "Monti Nebrodi".
Phytosociological table: Tabs. 4-5; taxonomic nomenclature according to Galasso et al. (2018).
Notes: In Sicily, geobotanical and phytosociological research conducted in recent years has made a significant contribution to the knowledge on distribution of various habitats and species of Community interest (Caldarella et al. 2013; De Castro et al. 2008, 2015; Gianguzzi and La Mantia 2008; Gianguzzi et al. 2010, 2016; 2020; Gianguzzi and Bazan, 2019, 2020; Marino et al. 2012, etc.). Regarding the habitat 6310 (Dehesas with evergreen *Quercus* spp.) it is rarely observed in Sicily, unlike Sardinia where

Table 4. Habitat 6310, related grassland within wooded pastures.

Relevé number	1
Cell ID	10kmE471N167
Latitude	38.02380
Longitude	14.49250
Date	10/16/2020
Area (m²)	200
Altitude (m a.s.l.)	140
Cover (%)	95
Slope (%)	25
Aspect	NW
Average vegetation height (cm)	10
Charact. and diff. taxa of *Cirsietalia vallis demonis* and *Molinio Arrhenatheretea*	
Lolium perenne L.	4
Cynosurus cristatus L.	3
Daucus carota L. subsp. *carota*	2
Dactylis glomerata L. subsp. *glomerata*	1
Prunella laciniata (L.) L.	+
Bromus hordeaceus L. subsp. *hordeaceus*	+
Oenanthe pimpinelloides L.	+
Anthoxanthum odoratum L.	+
Silene vulgaris (Moench) Garcke subsp. *vulgaris*	+
Holcus lanatus L. subsp. *lanatus*	+
Other species	
Mentha pulegium L. subsp. *pulegium*	3
^ *Quercus suber* L.	2
Dittrichia viscosa (L.) Greuter subsp. *viscosa*	2
Dittrichia graveolens (L.) Greuter	2
Asphodelus ramosus L. subsp. *ramosus*	2
Oxalis pes-caprae L.	2
Leontodon hispidus L. subsp. *hispidus*	2
Plantago lanceolata L.	2
Scolymus grandiflorus Desf.	1
Crepis vesicaria L. subsp. *vesicaria*	1
Trifolium repens L.	1
Carlina lanata L.	1
Reichardia picroides (L.) Roth	1
Hypericum perforatum L. subsp. *perforatum*	+
Sonchus asper (L.) Hill subsp. *asper*	+
Euphorbia helioscopia L. subsp. *helioscopia*	+
Polygonum aviculare L. subsp. *aviculare*	+
Portulaca oleracea L.	+
Hyparrhenia hirta (L.) Stapf subsp. *hirta*	+
Charybdis maritima (L.) Speta	+
Eryngium campestre L.	+
Bellis perennis L.	+
Rumex conglomeratus Murray	+
Crepis leontodontoides All.	+
Hyoseris radiata L.	+
Clinopodium nepeta (L.) Kuntze subsp. *nepeta*	+
Carex flacca Schreb. subsp. *erythrostachys* (Hoppe) Holub	+
Cichorium intybus L.	+
Prunella vulgaris L. subsp. *vulgaris*	+
Rumex thyrsoides Desf.	+
Helminthotheca echioides (L.) Holub	+
Carlina corymbosa L.	+

^ Reference plant species of the Habitat 6310, from Biondi et al. (2009).

Table 5. Habitat 6310, related hedgerow within wooded pastures.

Relevé number	1
Cell ID	10kmE471N167
Latitude	38.02270
Longitude	14.49350
Date	10/16/2020
Area (m²)	150
Altitude (m a.s.l.)	140
Cover (%)	100
Slope (%)	15
Aspect	NW
Average vegetation height (m)	3
Charact. and diff. taxa of *Quercetea ilicis*	
Myrtus communis L.	3
^ *Quercus suber* L.	2
Quercus gussonei (Borzì) Brullo	2
Pistacia lentiscus L.	2
Smilax aspera L.	2
Asparagus acutifolius L.	1
Clematis cirrhosa L.	1
Dioscorea communis (L.) Caddick & Wilkin	1
Euphorbia ceratocarpa Ten.	1
Olea europaea L. var. *sylvestris* (Mill.) Lehr	1
Rosa sempervirens L.	1
Rubia peregrina L.	1
Rubus ulmifolius Schott	1
Sorbus domestica L.	1
Genista monspessulana (L.) L.A.S.Johnson	+
Cytisus infestus (C.Presl) Guss. subsp. *infestus*	+
Euonymus europaeus L.	+
Other species	
Prunus spinosa L. subsp. *spinosa*	2
Arundo plinii Turra	1
Oloptum miliaceum (L.) Röser & H.R. Hamash	1
Ulmus minor Mill. subsp. *minor*	1
Fraxinus angustifolia Vahl subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso	1
Crataegus monogyna Jacq.	1
Cistus monspeliensis L.	1
Cistus salviifolius L.	+
Pteridium aquilinum (L.) Kuhn subsp. *aquilinum*	+
Spartium junceum L.	+
Bituminaria bituminosa (L.) C.H.Stirt.	+

^ Reference plant species of the Habitat 6310 from Biondi et al. (2009)

it is more common (Bagella 2016; Biondi et al. 2009). In fact, in Sicily this habitat is very rare and punctual, located in small areas at the edge of the forests of sub-mountainous and high-hilly belt (in particular Nebrodi, Peloritani, Etna and Madonie).

Interesting aspects of the habitat 6310 were detected along the valley of Buzza stream, near Caronia (ME), in the coastal area of Nebrodi Mts, on flysch formations with a thermo- and mesomediterranean subhumid bioclimate (Gianguzzi 2007).

The habitat has a clear anthropogenic origin due to the partial deforestation of *Quercus suber* wood, the cutting of shrub and soil plowing. It is a pasture quite peculiar in Sicily for its dual attitude. In fact, the pasture is grazed by cattle, sheep and horses, during most of the year, and by pigs (the native breed "Suino nero dei Nebrodi"), especially in autumn, in order to exploit the acorns production of cork oak (Fig. 4).

In the literature, only forest elements (*Quercus suber, Q. ilex* subsp. *ilex* and *Q. coccifera*) are indicated as typical species for this habitat, as well as some herbaceous taxa of *Poetea bulbosae* (Biondi et al. 2009; Bagella 2016). The floristic composition of this habitat is very heterogeneous in the Mediterranean area, also due to the fact that it actually refers to a vegetation mosaic. In the present paper, we report 2 phytosociological relevés representative of grasslands and shrublands related to Habitat 6310 in Sicily (Tabs. 4-5), linked to secondary aspects of the cork oak series and, in particular, to the pastures of *Cirsietalia vallis-demonii* (Brullo & Grillo 1978). For this area, we suggest that some herbaceous taxa such as *Lolium perenne*, *Cynosurus cristatus*, *Dactylis glomerata*, should be considered among the "reference plant species".

#19. Annex I Habitat: 9180* *Tilio-Acerion* forests of slopes, screes and ravines (Dagnino D, Mariotti M)

EUNIS Classification system: G1.A45 Thermophilous Alpine and peri-Alpine mixed Tilia forests
Biogeographical Region: Mediterranean
National Habitat Checklist of reference: Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE (Biondi et al. 2009).
P***hytosociological reference:*** *Tilio platyphylli-Acerion pseudoplatani* Klika 1955, *Fagetalia sylvaticae* Pawłowski in Pawłowski, Sokołowski & Wallisch 1928, *Querco roboris-Fagetea sylvaticae* Br.-Bl. & Vlieger in Vlieger 1937 (Biondi and Blasi 2015)
Geographic information: Italy, Liguria, Imperia, Ponte dei Passi, between 750 and 800 m a.s.l., Coordinates: 7.83854 E, 44.02037 N (Tab. 6, Rel. 1).
Cells ID in the EEA reference grid: 10kmE414N232 (Fig. 5).
Natura 2000 Site Code: currently not included in any Natura 2000 Site.
Phytosociological table: Tab. 6; taxonomic nomenclature according to Bartolucci et al. (2018) and later updates, and Aleffi et al. (2020).
Notes: The finding occurred during the activities for the Interreg ALCOTRA CoBiodiv and GeBiodiv projects. The habitat occupies a narrow belt within the ravines near the confluence of three montane creeks (i.e., Teroselli, Giurè and Conchè). Despite the phytosociological relevé was performed outside the border, the patch of habitat ex-

Figure 3. Distribution in Italy of the Habitat 6310: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013-2018; Eionet 2019).

Figure 4. Aspect of dehesas with *Quercus suber* in the valley of Torrente Buzza (Caronia, Nebrodi Mts, Sicily).

Table 6. Habitat 9180*; specific cover values are expressed as percentage.

Relevé number	1
Cell ID	10kmE414N232
Latitude	44.02037
Longitude	7.83854
Date	6/10/2020
Area (m²)	200
Altitude (m a.s.l.)	760
Exposition	W-NW
Slope (°)	45
Total cover (%)	85
Tree layer cover (%)	80
Shrub layer cover (%)	35
Herb layer cover (%)	55
Bryophyte layer cover (%)	15
Charact. and diff. taxa of *Tilio platyphylli-Acerion pseudoplatani*, *Fagetalia sylvaticae*, *Querco roboris-Fagetea sylvaticae*	
^ *Acer opalus* Mill. subsp. *opalus*	30
^ *Acer campestre* L.	30
^ *Corylus avellana* L.	25
Hedera helix L. subsp. *helix*	20
^ *Tilia platyphyllos* Scop. subsp. *cordifolia* (Besser) C.K. Schneid.	10
^ *Carpinus betulus* L.	10
Geranium nodosum L.	10
^ *Ostrya carpinifolia* Scop.	5
Festuca heterophylla Pourr.	5
Cornus sanguinea L.	5
Melica uniflora Retz.	5
Dioscorea communis (L.) Caddick & Wilkin	5
Hepatica nobilis Mill.	5
Crataegus monogyna Jacq.	1
Daphne laureola L.	1
Primula veris L. subsp. *columnae* (Ten.) Maire & Petitm.	+
Carex digitata L.	+
Sanicula europaea L.	+
Ilex aquifolium L.	+
Melittis melissophyllum L. subsp. *melissophyllum*	+
Primula vulgaris Huds. subsp. *vulgaris*	+
Digitalis lutea L.	+
Carex sylvatica Huds.	+
^ *Polystichum setiferum* (Forssk.) T. Moore ex Woyn.	+
Luzula nivea (Nathh.) DC.	+
Pulmonaria vallarsae A. Kern. subsp. *apennina* (Cristof. & Puppi) L. Cecchi & Selvi	+
Other species	
Exsertotheca crispa (Hedw.) S.Olsson, Enroth & D.Quandt	5
Homalothecium lutescens (Hedw.) H.Rob. var. *lutescens*	5
Eurhynchium striatum (Hedw.) Schimp.	5
Rosa sp.	5
Sesleria cfr. *autumnalis* (Scop.) F.W. Schultz	5
Emerus major Mill. subsp. *major*	1
Rubus sp.	1
Symphytum tuberosum L. subsp. *angustifolium* (A. Kern.) Nyman	1
Carex brachystachys Schrank	1
Saxifraga cuneifolia L. subsp. *cuneifolia*	1
Porella arboris-vitae (With.) Grolle subsp. *arboris-vitae*	1
Aegopodium podagraria L.	+
Polypodium interjectum Shivas	+
Tanacetum cfr. *corymbosum* (L.) Sch. Bip.	+
Asplenium trichomanes L.	+
Vicia sepium L.	+
Epipactis sp.	+
Senecio nemorensis aggr.	+
Viola sp.	+
Helleborus foetidus L. subsp. *foetidus*	+
Dryopteris cambrensis (Fraser-Jenk.) J. Beitel & W.R. Buck subsp. *insubrica* (Oberh. & Tavel ex Fraser-Jenk.) Fraser-Jenk.	+
Anomodon viticulosus (Hedw.) Hook. & Taylor	+

Table 6. Continuation.

Relevé number	1
Cell ID	10kmE414N232
Latitude	44.02037
Longitude	7.83854
Date	6/10/2020
Area (m²)	200
Altitude (m a.s.l.)	760
Exposition	W-NW
Slope (°)	45
Total cover (%)	85
Tree layer cover (%)	80
Shrub layer cover (%)	35
Herb layer cover (%)	55
Bryophyte layer cover (%)	15
Rhynchostegium confertum (Dicks.) Schimp.	+
Plagiomnium undulatum (Hedw.) T.J.Kop. var. *undulatum*	+
Fissidens taxifolius Hedw.	+
Ctenidium molluscum (Hedw.) Mitt.	+
Tortella nitida (Lindb.) Broth.	+

^ Reference plant species of the Habitat 9180*, from Biondi et al. (2009).

Figure 5. Distribution in Italy of the Habitat 9180*: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013-2018; Eionet 2019).

tends into the nearby Natura 2000 Site SAC IT1314609 "Monte Monega - Monte Prearba" without interruption.

#20. Annex I Habitat: 92A0 *Salix alba* and *Populus alba* galleries (Dagnino D, Turcato C)

EUNIS Classification system: G1.31 - Mediterranean riparian *Populus* forests
Biogeographical Region: Mediterranean
National Habitat Checklist of reference: Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE (Biondi et al. 2009).
Phytosociological reference: *Populion albae* Br.-Bl. ex Tchou 1948, *Populetalia albae* Br.-Bl. ex Tchou 1948, *Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantó ex Rivas-Martínez, Báscones, T.E. Díaz, Fernández-González & Loidi 2001 (Biondi and Blasi 2015).
Geographic information: Italy, Liguria, Carasco, San Quirico, 20 m a.s.l., Coordinates: 9.35769 E, 44.352737 N (Tab. 7, Rel. 1).
Cells ID in the EEA reference grid: 10kmE426N236 (Fig. 6).
Natura 2000 Site Code: SAC IT1332717 "Foce e medio corso del fiume Entella"
Phytosociological table: Tab. 7; taxonomic nomenclature according to Bartolucci et al. (2018) and Galasso et al. (2018), and later updates.

Notes: The finding occurred during the field surveys for the implementation of the SAC Management Plan. Although reported by Mariotti (2008) for the Entella river, the presence of the Habitat in the indicated cell has not been included in the Article 17 Habitats Directive IV Report (Eionet 2019). The habitat occupies a narrow part of the Entella river banks on the left orographic side. The habitat is degraded by the abundance of exotic species, as well as by the significant anthropic impact.

Errata Corrige

The recently published "New national and regional Annex I Habitat records: from #13 to #15" (Gianguzzi et al. 2020), published in this journal (Plant Sociology 57(1): 65–74), makes a wrong reference to the Habitat code 7120 instead of 7210*, in both figure and table captions. As correctly indicated in the text, the record refers unmistakeably to Habitat 7210*.

In the same paper, the geographical coordinates in Tabs. 2 and 3 appeared to be modified due to the wrong cell format. Also in this case, the coordinates are correctly indicated in the text.

Hereafter the corrected version of the *errata* is shown in Tab. 8.

Figure 6. Distribution in Italy of the Habitat 92A0: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013-2018; Eionet 2019).

Table 7. Habitat 92A0; specific cover values are expressed as percentage.

Relevé number	1
Cell ID	10kmE426N236
Latitude	44.352737
Longitude	9.35769
Date	7/23/2020
Area (m²)	200
Altitude (m a.s.l.)	20
Exposition	S
Slope (°)	1
Total cover (%)	100
Tree layer cover (%)	80
Shrub layer cover (%)	50
Herb layer cover (%)	20
Charact. and diff. taxa of *Populion albae*, *Populetalia albae*, *Salici purpureae-Populetea nigrae*	
^ *Populus nigra* L.	30
^ *Populus alba* L.	30
^ *Salix alba* L.	25
^ *Humulus lupulus* L.	10
^ *Convolvulus sepium* L.	5
^ *Sambucus nigra* L.	1
Carex pendula Huds.	1
Salix purpurea L. subsp. *purpurea*	+
Other species	
Helianthus tuberosus L.	10
Persicaria maculosa Gray	10
Rubus sp.	5
Arundo donax L.	5
Xanthium italicum Moretti	5
Pittosporum tobira (Thunb.) W.T.Aiton	5
Acer saccharinum L. subsp. *saccharinum*	5
Tradescantia fluminensis Vell.	+
Parthenocissus quinquefolia (L.) Planch.	+
Dysphania ambrosioides (L.) Mosyakin & Clemants	+
Plantago major L.	+
Passiflora caerulea L.	+

^ Reference plant species of the Habitat 92A0, from Biondi et al. (2009).

Table 8. Errata corrige referring to "New national and regional Annex I Habitat records: from #13 to #15" (Gianguzzi et al. 2020).

page	*erratum*	*corrige*
67 (Tab. 2, Latitude, Longitude)	4.516.735, 1.070.986	45.16735, 10.70986
	4.516.682, 1.070.964	45.16682, 10.70964
68 (Tab. 3, caption)	Habitat 7120*	Habitat 7210*
68 (Tab. 3, Latitude, Longitude)	41.046.760, 8.936.343	41.046760, 8.936343
	41.046.661, 8.936.558	41.046661, 8.936558
	41.046.535, 893.668	41.046535, 8.936687
69 (Fig. 2, caption)	Distribution in Italy of the Habitat 7120*	Distribution in Italy of the Habitat 7210*

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PENSOFT

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First syntaxonomical contribution to the invasive *Ailanthus altissima* (Mill.) Swingle forest communities at its southern limit in Europe

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Abstract

Ailanthus altissima (tree of heaven), an invasive alien tree native to China, has become invasive all over the world and in Italy is present in all the administrative regions where it can form dense forest communities. Although there are several ecological studies on this species there is a lack of floristic-vegetational data for southern-Europe. The study presents the results of a floristic vegetational study on *A. altissima* forest communities of central Italy that aims to highlight the possible floristic-vegetational autonomy of these coenoses. The results have allowed the characterization of *A. altissima* coenoses at the ecological, biogeographic, syntaxonomic and landscape levels. These represent first *A. altissima* syntaxa described for the Italian peninsula and for southern-Europe. We propose two new sub-Mediterranean and Mediterranean associations comprised in the recently described alliance *Lauro nobilis-Robinion pseudoaciae*, in the *Chelidonio-Robinietalia* order and the *Robinietea* class: *Asparago acutifolii-Ailanthetum altissimae*: forest community with stratified structure and high canopy density on the warmer slopes of the hills in dry soil conditions and low anthropic disturbance and *Aro italici-Ailanthetum altissimae*: paucispecific forest communities with a monolayered structure typically found in agricultural, and peri-urban areas on pelitic, alluvial silty-sandy substrates, in conditions of edaphic humidity and high anthropogenic disturbance. The comparison with literature data highlights the autonomy of these associations of the sub-Mediterranean and Mediterranean alliance *Lauro nobilis-Robinion* pseudoacaciae alliance from the *Balloto nigrae-Ailanthetum altissimae* association of the Central and SE-European *Balloto nigrae-Robinion pseudoacaciae* alliance.

Keywords

Ailanthus altissima, alien forest communities, invasive alien species, Mediterranean and sub-Mediterranean climate, plant landscape, *Robinietea* class, syntaxonomy

Introduction

The invasion of alien plants is a global process derived from the human–mediated introduction of a species outside their habitat of origin (Richardson and Pyšek 2006; Van Kleunen et al. 2015). Biological invasions constitute one of the major threats to biodiversity and ecosystem services provided by native ecosystems (Simberloff et al. 2013; Lazzaro et al. 2020; Montecchiari et al. 2020a) causing both ecological, economical and health impacts (Lonsdale 1999; Pimentel et al. 2000; Touza et al. 2008; Vilà and Hulme 2017).

Ailanthus altissima is one of the most widespread invasive alien species (IAS) in Europe (Lambdon, et al. 2008; Pysek et al. 2009) and was recently added to the list of IAS of Union concern (European commission 2019). It is a tree native to China and introduced in Europe (France) in 1740 (Kowarik and Saumel 2007). It quickly spread in Central and southern Europe in urban and peri–urban areas, but also in the agro–forest environment (Gutte et al. 1987; Udvardy 1998; Howard et al. 2004) due to cultivations for ornamental, productive and erosion control purposes (Hu 1979; Udvardy 1998; Kowarik and Säumel 2007; Badalamenti et al. 2012). Its first record for the Italian territory dates back to 1760 in the Botanical Garden of Padua (Badalamenti et al. 2012). Now is present in all the Italian administrative regions (Galasso et al. 2018) classified as invasive alien species because it can constitute proper forest communities (Montecchiari et al. 2020b; Viciani et al. 2020) capable to impact native ecosystems and Natura 2000 sites (Lazzaro et al. 2020). Moreover, according to the National Forest Inventory (Tabacchi et al. 2007), which classifies in a single category the *A. altissima* and *R. pseudoacacia* and forests, these formations together occupy almost 250000 ha, equal to 2.23% of the total national wooded area.

The efficacy in gamic reproduction and dissemination (Knapp and Canham 2000; Motard et al. 2011), agamic reproduction (Kowarik 1995; Kowarik and Saumel 2007, Von der Lippe et al. 2013) and rapid growth, enable *A. altissima* to form nearly pure stands (Dihoru and Doniță 1970; Montecchiari et al. 2020b) and to have better competitive ability compared to the forest native species (Arnaboldi et al. 2002; Fotiadis et al. 2011; Höfle et al. 2014; Costàn-Nava et al. 2015). Moreover, the production of an allelopathic compound (Ailanthone) from the bark and leaves, can inhibit the germination of native species (Lawrence et al. 1991; Bostan et al. 2014). It shows a high tolerance to limiting ecological factors such as soil type and drought with several adaptations to water loss (Kowarik and Saumel 2007; Sladonja et al. 2015). *A. altissima* is better adapted to warmer climate regimes, in fact, it shows a high susceptibility to cold that is a limiting factor for the sapling survival (von der Lippe et al. 2005). Badalamenti et al. (2012) reports that *A. altissima* avoids excessively clay soils or soils subject to prolonged water stagnation. Thanks to its highly competitive features *A. altissima* can establish in a wide variety of environmental conditions and is able to form dense forest population that can also impact soil properties and nutrient cycling (Vilà et al. 2006; Gómez-Aparicio et al. 2008; Castro-Díez et al. 2009; Medina-Villar et al. 2015; Motard et al. 2015; Montecchiari et al. 2020b). Despite the many ecological data available and its wide distribution in the Mediterranean and Temperate Europe, there is an important lack of floristic-vegetational studies on *A. altissima* forests in its meridional range of distribution, in sub-Mediterranean and Mediterranean areas. From a syntaxonomic point of view, in Europe is recognized only one class (with two orders and three alliances) that comprehends alien tree species as characteristic species: the *Robinietea* class. It includes "seral forest-clearing and anthropogenic successional scrub and thickets on nutrient-rich soils of temperate Europe" (Mucina et al. 2016) but it includes also thermophilus and xerophilous communities such as those of the *Euphorbio cyparissiae-Robinietalia* order defined as "tortuous and xerophilous Black Locust stands of thermophilus habitats" and on poor soils" (Vitkova and Kolbek 2010). Recently in Allegrezza et al. (2019) was described the *Lauro nobilis-Robinion pseudoacaciae* alliance for the peri-Adriatic sector of Central Italy, that brings together forest and pre–forest coenoses dominated by *R. pseudoacacia* that include forests communities dominated by other invasive alien tree species that have developed in the Mediterranean macroclimate territories of central and southern Italy that also extend into the temperate macroclimate of the sub-Mediterranean variant. Currently, in literature, there is only one *A. altissima* syntaxon, described for est-Romania by Sîrbu & Oprea (2010) called *Balloto nigrae-Ailanthetum altissimae*. This association is referred to the *Balloto nigrae-Robinion pseudoacaciae* alliance, *Chelidonio-Robinietalia pseudoacaciae* order *Robinietea* class. The association comprehend *A. altissima* communities situated between 38 and 265 m a.s.l. near human settlements, along roadsides-railway embankments, in abandoned agricultural areas and on the edge of *Robinia pseudoacacia* plantations that comprehends "heliophilous (sub-heliophilous), moderate thermophilous, xero-mesophilous, neutrophilous and moderate nitrophilous phytocoenoses" (Sirbu & Oprea 2010). Also, *A. altissima* communities of Slovakia were referred to *Balloto nigrae-Ailanthetum* association by Valachovic (2018). For central-Europe, there are other published floristic-vegetation data of *A. altissima* coenoses but described only at the community level. Those communities have been described without a clear syntaxonomical classification and referred to syntaxonomic classes other than the *Robinietea* class such as *Sisymbrietea*, *Chenopodietea*, *Artemisietea*, *Agropyretea* or *Urtico-Sambucetea*, *Cratego-Prunetea*, *Quercetea pubescenti–petraeae* classes (Gutte et al. 1987) or described as *Ailanthus*-woods with *R. pseudoacacia* and *Acer* species with a non-clear syntaxonomic attribution (Kowarik and Bocker 1984). Moreover, for the Mediterranean region, Kowarik (1983) reported on the colonization by the *A. altissima* in the French-Mediterranean region classifying the *A. altissima* communities according to the Hemeroby classification system. He reported only one relevè "the only *A. altissima* occurrence in a non-ruderalized *Quercion ilicis* stand is on the northern slope of the mountain range".

In literature is also cited *A. altissima* associations with no floristic-vegetational data linked to this syntaxons in literature such as *Ailantho altissimae-Robinietum pseudacaciae* Julve 2003 referred to *Robinio pseudoacaciae-Ulmion minoris* Julve 1993 alliance, *Pruno avium-Carpinetalia betuli* Gillet 1986 ex Julve 1993 order, *Fraxino excelsioris-Quercetea roboris* Gillet 1986 ex Julve 1993 class and the *Fico-Ailanthetum altissimae* Lov. (1975) 1984 ("*Ailantho-Robinietum*" auct. adriat. Pp non Gutte; Kvarner: "žiròvine").

For the Italian territory, there are only two published papers that describe *A. altissima* dominated vegetation: Fanelli (2002) described *A. altissima* forest community for the surroundings of the city of Rome and Sciandrello et al. (2017) described a *Rubus ulmifolius* shrub community in Sicily (*Pruno spinosae-Rubion ulmifolii*, *Pyro spinosae-Rubetalia ulmifolii*, *Crataego-Prunetea*) with *A. altissima* having cover–abundance values higher than 3 (Braun-Blanquet scale) in four relevés. In the present paper, we aimed to describe the structure, ecology and syntaxonomy of the *A. altissima* forest communities present in its southern limit of presence in Europe. Specifically, the aims of this syntaxonomic study are to i) extend the poor floristic-vegetational data available for *A. altissima* forests communities in the Italian peninsula; ii) define the *A. altissima* forest vegetational types at the community level and the ecological and landscape context in which they are found; iii) highlight the possible floristic-vegetational autonomy of these coenoses in the context of the *Robinietea* class in comparison with *A. altissima* floristic-vegetational data from Europe.

Study area

The study was conducted in central Italy (Marche-Abruzzo peri-Adriatic sector) (Figure 1) at altitudes that range from 10 m a.s.l. to 500 m a.s.l on pelitic-arenaceous, arenaceous-pelitic and alluvial lithotypes. The bioclimatic classification sensu Rivas-Martínez et al. (2011) for these territories indicates a Macrobioclimate that ranging from Mediterranean, pluviseasonal oceanic bioclimate and upper meso-Mediterranean thermotype to the Temperate sub-Mediterranean variant, oceanic bioclimate and lower meso-temperate thermotype (Pesaresi et al. 2014) according to the bioclimatic classification. The prevailing land use categories are mostly cops such as heterogeneous agricultural areas with complex cultivation patterns and non-irrigated arable land. The native forests vegetation consists of *Quercus pubescens*/*Q. virgiliana* woods on slopes referred to the alliance *Carpinion orientalis* (class *Querco roboris-Fagetea sylvaticae*), and riparian woods of *Salix alba* and *Populus nigra* referred to the alliance *Populion albae* (class *Salici purpureae-Populetea nigrae*). The high-shrub pre-forest vegetation is represented by *Ulmus minor* communities of the *Lauro nobilis-Ulmion minoris* alliance (class *Salici purpureae-Populetea nigrae*) (Blasi et al. 2010).

Materials and Methods

The study of the plant communities was carried out according to the phytosociological methods of the Zurich–Montpellier school (Braun-Blanquet 1928), updated according to the most recent acquisitions (Rivas-Martínez 2005; Allegrezza et al. 2008; Biondi 2011; Blasi and Frondoni 2011). We performed a total of 22 unpublished phytosociological relevés. The surveys were performed on *A. altissima* forests aged >20 years, where the alien tree was clearly dominant and over a minimum homogeneous area of 100 m². For the characterization of the *A. altissima* forests of the Italian peninsula, the unpublished relevés were analyzed along with 5 relevés from Fanelli (2002) that

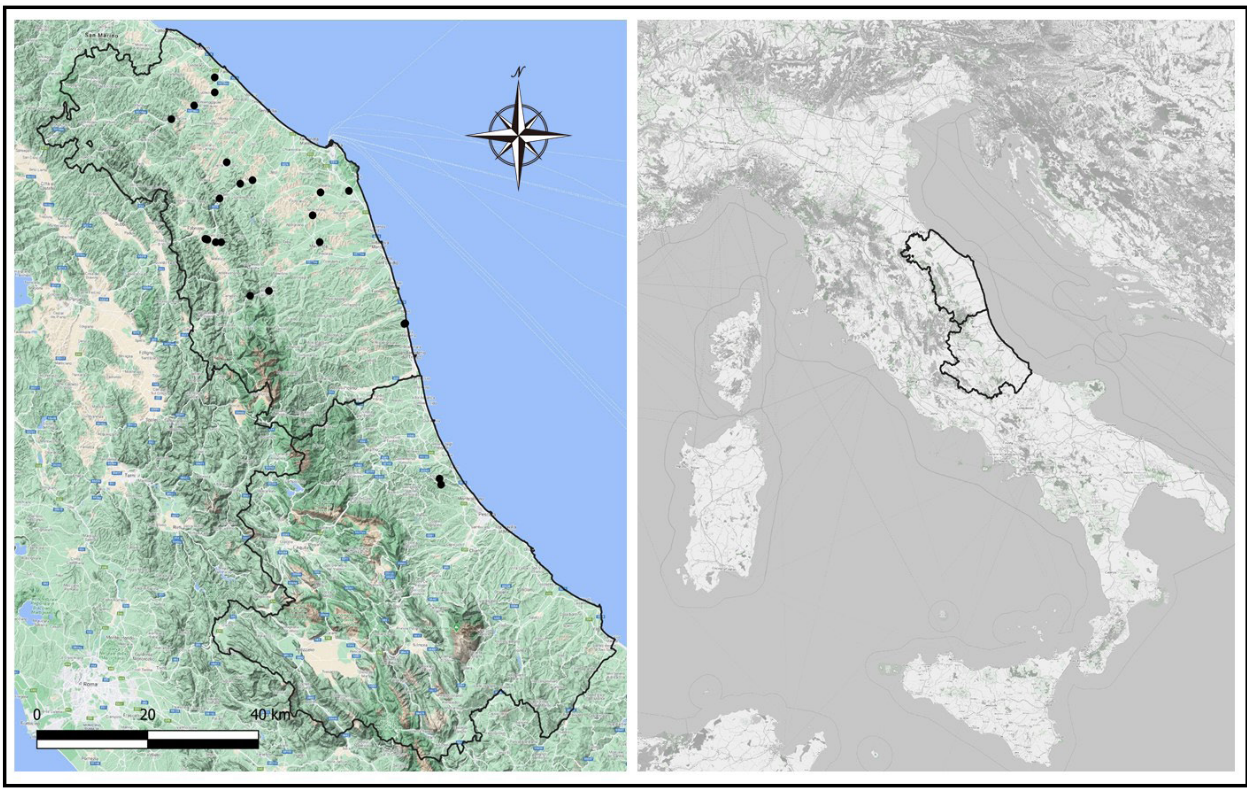

Figure 1. Study area. Location of the study area showing the distribution of the unpublished relevés. Each relevè is represented by a single black point.

described *A. altissima* community for the surrounding of Rome, because they have a forest structure, with clearly dominant *A. altissima*, having cover-abundance values higher than 3 (Braun-Blanquet scale) (see Appendix II). For the comparisons between the Italian peninsula and the European context we selected literature data that have been attributed to a syntaxon that includes *A. altissima* in the name and clearly dominant (cover-abundance values >3). Were used a total of 25 phytosociological relevés referred to the *Balloto nigrae-Ailanthetum altissimae* association respectively 20 from Sirbu & Oprea (2010) 5 from Valachovic (2018). The nomenclature of the species follows the check-list of Italian flora (Bartolucci et al. 2018). The life forms and chorology of the species follow Flora d'Italia (Pignatti et al. 2017–2019). For the Ellenberg indicators values (EIVs) (Ellenberg et al. 1992), we used the indices reformulated for the Mediterranean conditions (Pignatti et al. 2005): L light, T temperatures, C continentality; U soil moisture, R soil reaction, N availability of soil nutrients. The syntaxonomic classification is made according to the Prodrome of the Italian Vegetation (Biondi et al. 2014), as present on the updated site of the Italian Botanical Society (http://www. prodromovegetazioneitalia.org/), with references to that of the European vegetation (Mucina et al. 2016). The status of alien species (specifying between Archeophytes and Neophytes) has been assigned according to Galasso et al. (2018) and information on the national floras for the European data.

Data analysis

The vegetation data were processed using the "vegan" package (Oksanen et al. 2020) of the R software (R core team 2018). The cover–abundance values of the phytosociological matrix were converted to the Van der Maarel (1979) decimal scale and subjected to multivariate analysis. Before calculations, the ecological variables matrix was undergone at a normalization process using the "decostand" function on the "vegan" package. The numerical classification according to cluster analysis was carried out by applying the "Ward" link algorithm to the similarity ratio matrix calculated by applying the "Jaccard" index on the vegetation matrix converted in presence/absence values. Life forms of each relevè were weighted on the species abundance values and then averaged at the group level. To compare EIVs of the plots, we used weighted average values. Box plot diagrams were used to illustrate data distribution of Life forms and EIVs. To analyze the variance of the groups and tests for significance we used ANOVA (supplementary materials, Table S1) ("aov" function of "stats" package). The Shapiro test was used to test the normality of the analyzed data and the Bartlett test for homoscedasticity.

For the comparison with the published European data, we create a unique phytosociological matrix, converted to the Van der Maarel (1979) decimal scale and subjected to multivariate analysis. The similarity matrix obtained applying the "Jaccard" index was used to perform non–metric multidimensional (NMDS) ordination diagram. The NMDS ordination diagram is suitable for the analysis of ordinal data such as those of Van der Maarel (Podani 2007) and was used to describe the main trends of the vegetation variations. Percentage weighted presence of chorological types and alien species for each plot was calculated and illustrated by box plots. Then we performed the analysis of variance and tested the significance among the averages of the identified groups.

Results and Discussion

The dendrogram (Fig. 2a) obtained from the classification of phytosociological relevès highlights two main groups (Cluster I and Cluster II) which correspond to the two main structural, ecological and floristic–vegetational characteristics of the *A. altissima* forest communities. The comparison of the statistically significant traits such as functional (life forms) and ecological traits (EIVs), highlights the structural and ecological differences between the two groups. The first group (Cluster I) differs for the higher coverage of phanerophytes (Fig. 2b.2) and thermophilous species (Temperature EIV) (Fig. 2b.4) while the second group (Cluster II) is characterized by the higher coverage of herbaceous species such as Geophytes and Terophytes (Fig. 2b.1 and 2b.3). The processing of the relevès in Table 1 and the comparison with the similar phytocoenoses described for south–est Europe allows us to propose and describe two new associations of *A. altissima* forest vegetation within the sub– Mediterranean alliance *Lauro nobilis-Robinion pseudoacaciae* (order *Chelidonio-Robinietalia pseudoacaciae* and class *Robinietea*): *Asparago acutifolii-Ailanthetum altissimae* (cluster I) and *Aro italici-Ailanthetum altissimae* (Cluster II).

ASPARAGO ACUTIFOLII–AILANTHETUM ALTISSIMAE ass. nova (Cluster I Fig. 2; *typus* rel. 7 of Tab. 1)

It is a sub-Mediterranean and Mediterranean forest community dominated by *A. altissima* characterized by a stratified structure and high canopy density, with an average height of 13.6 and an average richness of 16 species per relevè. It is typically present on the warmer slopes of the hills (up to 460 m a.s.l.) with arenaceous-pelitic, arenaceous and locally calcareous substrates, in dry soil conditions and in areas subject to low anthropic disturbance (the surrounding landscape is characterized by the greater presence of forest areas). In the dominated tree and shrub layer are frequent forest species of the *Querco-Fagetea* class such as *Hedera helix*, *Acer campestre*, *Quercus pubescens*, *Fraxinus ornus* and pre-forest and shrub species of the *Rhamno-Prunetea* class such as *Rubus ulmifolius*, *Clematis vitalba*, *Ulmus minor*. Those species indicate that the potential native vegetation for the territory occupied by the *A. altissima* forest of the *Asparago acutifolii-Ailanthetum altissimae* is the Mediterranean and sub-Mediterranean oak forests of the *Carpinion orientalis* alliance, referring to the habitat of community interest 91AA (92/43/EEC Habitats Directive). Characteristic and differential species of the new association are *A. altissima*, *Hedera helix*, *Acer campestre*, *Quercus pubescens*, *Fraxinus ornus*, *Prunus spinosa, Asparagus acutifolius* and *Olea europaea*. The new association refers to the *Lauro nobilis-Robinion pseudoacaciae* alliance because of the presence of characteristic species of this syntaxon such as *Rubus ulmifolius*, *Laurus nobilis*, *Melissa officinalis* subsp. *altissima*, *Rubia peregrina*, *Parietaria diffusa*, *Viola alba* subsp. *dehnhardtii*, *Ficus carica*, *Ligustrum vulgare*, *Rosa sempervirens*, *Rhamnus alaternus*, *Avena barbata*, etc. The characteristic species of the order *Chelidonio-Robinetalia pseudoacaciae* and *Robinietea* class except for *A. altissima* (*Robinietea* class) are present locally and with low coverage values especially in the xerophilous aspects similarly to what happens for the thermophilous communities of the association *Rubio peregrinae-Robinietum pseudoacaciae* (Allegrezza et al. 2019). However, as highlighted in Allegrezza et al. (2019), the *Lauro nobilis-Robinion pseudoacaciae* alliance includes, in addition to the typically nitrophilous aspects on soils rich in organic matter, also xerophilous

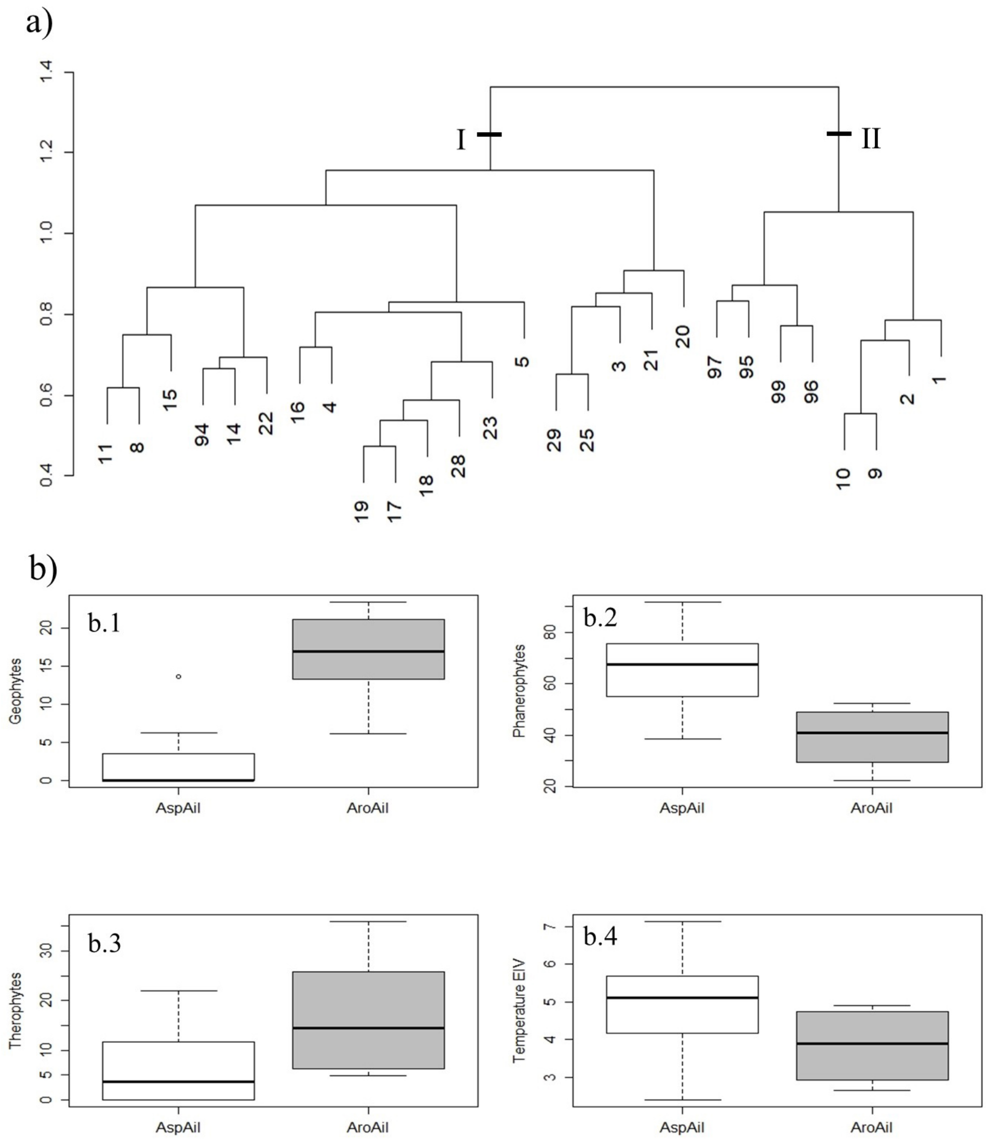

Figure 2. Classification of the Italian *A. altissima* forest communities and box plots of the life forms. (a) Dendrogram from the phytosociological relevés of the *A. altissima* communities in the study area and published relevés from Fanelli (2002). Cluster I, *Asparago acutifolii-Ailanthetum altissimae*; Cluster II, *Aro italici-Ailanthetum altissimae*. (b) Comparison of the significant life form and EIVs of the two *A. altissima* forest associations (AspAil: *Asparago acutifolii-Ailanthetum altissimae* and AroAil: *Aro italici-Ailanthetum altissimae*) through box plots. (b.1) Geophytes p value <0,0001, (b.2) Phanerophytes p value <0,0001; (b.3) Terophytes p value = 0.001; (b.4) Temperature EIV p value =0.04.

Table 1. Mediterranean and sub-Mediterranean *A. altissima* forest communities belong to the alliance *Lauro nobilis-Robinion pseudoacaciae*. *Asparago acutifolii-Ailanthetum altissimae* ass. nova (rels 1–19, *typus* rel. 7); *Aro italici-Ailanthetum altissimae* ass. nova (rels 20–27, *typus* rel. 22).

Life form	N° rel.	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	22^	21	23	24	25	26	27	Pres.	Freq. Gr. I	Freq. Gr. II
	N° rel. from dendrogram fig. 2	29	25	20	3	21	5	23	28	18	17	19	4	16	15	22	14	94	8	11	9	10	2	1	97	96	99	95			
	N° cluster from dendrogram fig. 2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II			
	Altitude [m o.s.l.]	114	38	310	97	462	28	162	80	308	359	268	40	301	140	179	50		152	460	114	97	330	350							
	Aspect	S	SE	S	S	E	NO	NE	E	E	NE	N	SO	NO	SE	NO	SE	SO	NO	O	O	E	SE	S	O	SE	O	NO			
	Slope [°]	30	10	15	30	15	20	25	35	5	15	15	20	15	15	10	10	5	35	40	-	-	5	25	45	2	1	15			
	Area [mq]	200	100	100	90	400	350	250	250	100	100	250	150	100	250	150	300	100	150	120	200	200	100	150	80	80	80	50			
	Total cover [%]	90	90	90	90	85	97	95	90	90	100	95	90	95	99	85	95		98	95	95	50	100	90							
	Tree layer height [m]	8	13	19	8.3	10	19	20	14	11	12	20	9	13	13	8	14	20	15.8	11.4	14	8	10.5	8	15	20	15	7			
	N° species x rel.	17	14	19	18	16	22	23	16	15	12	17	16	25	17	7	13	14	12	17	12	14	15	14	15	11	16	13			
	***Asparago acutifolii-Ailanthetum altissimae* ass. nova**																														
P lian	*Hedera helix* L.	3.3	1.1			3.3	2.2	4.4	2.2	4.4	5.5	4.4	2.3	+.2	+		3.3	4	+	+		1.2		1.1					18	V	II
P scap	*Acer campestre* L.			+			+		1.1	2.2	2.2	+	+	+	+	+				1.2									11	III	
P caesp	*Quercus pubescens* s.l. Willd.	+		+	+			+					+	1.1					2.2	1.2									8	III	
P scap	*Fraxinus ornus* L.	+		+		1.1		+				+																	5	II	
G rhiz	*Asparagus acutifolius* L.	1.1	+		2.3	1.1	1.1	+	1.1				+										+				+		10	II	II
P caesp	*Prunus spinosa* L.					1.1	+	+	+	+	+	+					1.1												8	III	
P caesp	*Olea europaea* L.			+	+.2										+				+	+									5	II	
	***Aro italici-Ailanthetum altissimae* ass. nova**																														
G rhiz	*Arum italicum* Mill.																	+			1.2	1.2	1.1	3.3	1	+	+	+	9	I	V
G rhiz	*Elymus repens* (L.) Gould subsp. *repens*																				1.2	1.2	3.3						3		III
G rhiz	*Convolvulus arvensis* L.																				+	+		+					3		III
H caesp	*Poa trivialis* L.						+																			+	+	+	4	I	III
	Lauro nobilis-Robinion pseudoacaciae																														
NP	*Rubus ulmifolius* Schott	1.1	+		+	2.2	+	2.2	2.2	+	+	1.1	2.3	1.1		5.5	+	+	+		3.3	+.2	+.2		+	+			21	V	IV
P caesp	*Laurus nobilis* L.	+		+				1.1	+		1.1				+	+	+	2	+			1.2				+			12	III	II
H scap	*Melissa officinalis* subsp. *altissima*	+					+		+			+		+	+					1.1	1.2	+.2	2.2						10	II	III
P lian	*Rubia peregrina* L.	+			+	+		2.2					2.2														1		6	II	I
H scap	*Parietaria diffusa* M. et K.				+								+					+					+.2	+				1	6	I	III
T scap	*Anisantha diandra* (Roth) Tutin ex Tzvelev	1.1	1.1		+																1.2		1.1						5	I	II
T scap	*Avena barbata* Potter				+		2.2																+	1.1		+			5	I	III
H ros	*Viola alba* Besser subsp. *dehnhardtii* (Ten.) W.Becker							+		+				+								+.2							4	I	I
P scap	*Ficus carica* L.																			+.2		1.2		+					3	I	II
NP	*Ligustrum vulgare* L.								+	2.2				2															3	I	
P caesp	*Rhamnus alaternus* L.				1.2								1.1														1		3	I	I
H caesp	*Brachypodium rupestre* (Host) R. et S.			+										+															2	I	
G bulb	*Bellevalia romana* (L.) Sweet			+																									1	I	
P scap	*Juglans regia* L.							+																1.1					2	I	I

Table 1. Continuation.

Life form	N° rel.	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	22^	21	23	24	25	26	27	Pres.	Freq. Gr. I	Freq. Gr. II
	N° rel. from dendrogram fig. 2	29	25	20	3	21	5	23	28	18	17	19	4	16	15	22	14	94	8	11	9	10	2	1	97	96	99	95			
	N° cluster from dendrogram fig. 2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II			
	Altitude [m o.s.l.]	114	38	310	97	462	28	162	80	308	359	268	40	301	140	179	50		152	460	114	97	330	350							
	Aspect	S	SE	S	S	E	NO	NE	E	E	NE	N	SO	NO	SE	NO	SE	SO	NO	O	O	E	SE	S	O	SE	O	NO			
	Slope [°]	30	10	15	30	15	20	25	35	5	15	15	20	15	15	10	10	5	35	40	-	-	5	25	45	2	1	15			
	Area [mq]	200	100	100	90	400	350	250	250	100	100	250	150	100	250	150	300	100	150	120	200	200	100	150	80	80	80	50			
	Total cover [%]	90	90	90	90	85	97	95	90	90	100	95	90	95	99	85	95		98	95	95	50	100	90							
	Tree layer height [m]	8	13	19	8.3	10	19	20	14	11	12	20	9	13	13	8	14	20	15.8	11.4	14	8	10.5	8	15	20	15	7			
	N° species x rel.	17	14	19	18	16	22	23	16	15	12	17	16	25	17	7	13	14	12	17	12	14	15	14	15	11	16	13			
NP	*Rosa sempervirens* L.							+																			+		2	I	I
H bienn	*Inula conyzae* (Griess.) DC.			+																									1	I	
P scap	*Quercus ilex* L.					+																							1	I	
G rhiz	*Ruscus aculeatus* L.							+																					1	I	
G rhiz	*Arundo plinii* Turra												+.3																1	I	
G rhiz	*Chamaeiris foetidissima* (L.) Medik.																	+											1	I	
T scap	*Sinapis alba* L.																						+.2						1		I
	Chelidonio-Robinietalia* and *Robinietea																														
P scap	*Ailanthus altissima* (Mill.) Swingle	4.4	3.3	3.3	4.4	4.4	5.5	3.3	4.4	4.4	5.5	4.4	4.4	5.5	4.4	4.4	4.4	5	4.4	4.5	4.4	4.4	4.4	4.4	4	5	5	5	27	V	V
P caesp	*Sambucus nigra* L.						+	+				3.3	+	2.2			+	+	2.2					+					9	III	I
T scap	*Galium aparine* L.																		+	1.1		+.2		2.2	4	+	+	1	8	I	IV
H scap	*Urtica dioica* L.											+					+	+	+	+	+.2	+			2				8	II	III
P caesp	*Robinia pseudoacacia* L.							1.1	+			+	1.1										+	+.2	1				7	II	III
T scap	*Chaerophyllum temulum* L.						3.3	+				+			+		+			+-2									6	II	
T scap	*Anisantha sterilis* (L.) Nevski														+			+		+					1			2	5	I	II
H bienn	*Alliaria petiolata* (M.Bieb.) Cavara & Grande						+									+	+								+				4	I	I
H scap	*Lamium maculatum* L.									+	+	+		+															4	II	
H caesp	*Dactylis glomerata* L.		+		+															+.2									3	I	
H scap	*Geum urbanum* L.						+																						1	I	
T rept	*Stellaria media* (L.) Vill.																											+	1		I
H scap	*Ballota nigra* L.																							1.1					1		I
G rhiz	*Bryonia dioica* Jacq.																											1	1		I
T scap	*Fallopia convolvulus* (L.) Holub																								+				1		I
H scap	*Anthriscus sylvestris* (L.) Hoffm.																									+			1		I
	Others																														
P lian	*Clematis vitalba* L.	+		+		+		+	+	+	3.3	+	1.1	1.1	+	+		+	+	3.3	1.2	+.2	+	1.1					19	IV	III
P caesp	*Crataegus monogyna* Jacq.	+	+				+	+	+	1.1	+	+		+	+								+				+		12	III	II
P scap	*Prunus avium* (L.) L.							+			+	+		1.1															4	II	
P caesp	*Cornus sanguinea* L.							+	+	+	1.1	2.2	+	1.1					+	+.2	1.2						+		11	III	II
P caesp	*Ulmus minor* Miller										+		+	+	2.2	+	2.2	+		1.2								+	9	III	I

Table 1. Continuation.

Life form		1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	22^	21	23	24	25	26	27	Pres.	Freq. Gr. I	Freq. Gr. II
	N° rel. from dendrogram fig. 2	29	25	20	3	21	5	23	28	18	17	19	4	16	15	22	14	94	8	11	9	10	2	1	97	96	99	95			
	N° cluster from dendrogram fig. 2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II			
	Altitude [m o.s.l.]	114	38	310	97	462	28	162	80	308	359	268	40	301	140	179	50		152	460	114	97	330	350							
	Aspect	S	SE	S	S	E	NO	NE	E	E	NE	N	SO	NO	SE	NO	SE	SO	NO	O	O	E	SE	S	O	SE	O	NO			
	Slope [°]	30	10	15	30	15	20	25	35	5	15	15	20	15	15	10	10	5	35	40	-	-	5	25	45	2	1	15			
	Area [mq]	200	100	100	90	400	350	250	250	100	100	250	150	100	250	150	300	100	150	120	200	200	100	150	80	80	80	50			
	Total cover [%]	90	90	90	90	85	97	95	90	90	100	95	90	95	99	85	95		98	95	95	50	100	90							
	Tree layer height [m]	8	13	19	8.3	10	19	20	14	11	12	20	9	13	13	8	14	20	15.8	11.4	14	8	10.5	8	15	20	15	7			
	N° species x rel.	17	14	19	18	16	22	23	16	15	12	17	16	25	17	7	13	14	12	17	12	14	15	14	15	11	16	13			
P caesp	*Euonymus europaeus* L.	1.1	+	+			1.1	+		+		1.1			+						+.2								9	III	I
H scap	*Clinopodium nepeta* (L.) Kuntze		+		+									1.1						+.3									4	II	
P caesp	*Paliurus spina christi* Miller		1.1	+					+																				3	I	
H scap	*Galium album* Miller	+	+											+															3	I	
H caesp	*Brachypodium sylvaticum* (Huds.) Beauv.					5.5			1.1																		+		3	I	I
P scap	*Cercis siliquastrum* L.	+		1.1																									2	I	
NP	*Rubus caesius* L.	1.1																									+		2	I	I
H scap	*Picris hieracioides* L.		+											+															2	I	
NP	*Osyris alba* L.			+		+																							2	I	
T scap	*Torilis arvensis* (Hudson) Link		1.1												+														2	I	
H scap	*Rumex obtusifolius* L.																									+	+		2		II
P caesp	*Prunus domestica* L.						+		+																				2	I	
NP	*Rosa canina* L.					1.1								+															2	I	
H scap	*Cruciata glabra* (L.) Ehrend.						+.2							+															2	I	
H ros	*Silene italica* (L.) Pers.						+										+												2	I	
H caesp	*Carex pendula* Huds.									+												+							2	I	I
P lian	*Lonicera japonica* Thunb.												3.2														1		2	I	I
G rhiz	*Arundo donax* L.						+																	+					2	I	I
H bienn	*Silene latifolia* Poiret													+											+				2	I	I
H scap	*Stachys sylvatica* L.																+											+	2	I	I
P scap	*Populus nigra* L.									+											+.2								2	I	I
	Sporadics species	1	1	5	6	4	3	2	-	1	-	-	-	3	4	-	1	2	1	1	-	-	2	-	5	2	2	3			

and thermophilous communities on dry soils in poorly anthropized contexts (Allegrezza et al. 2019).

Compared to the *Rubio peregrinae-Robinietum pseudoacaciae* association described by Allegrezza et al. (2019) for the same study area, the floristic composition of the new association *Asparago acutifolii-Ailanthetum altissimae* essentially differs for the lower species richness and coverage of mesophilous and nitrophilous species such as *Sambucus nigra* denoting for the *A. altissima* forests a stronger thermophilous and xerophilous character, in accordance with what is reported in the literature on the ecology of *A. altissima* (e.g. Sladonja et al. 2015).

ARO ITALICI–AILANTHETUM ALTISSIMAE ass. nova (Cluster II Fig. 2; *typus* rel. 22 of Tab. 1).

The new association refers to the *A. altissima* sub-Mediterranean and Mediterranean paucispecific forest communities characterized by a monolayered structure, with a with an average height of 12 m, and an average richness of 13 species per relevè. These forest coenoses are typically found in agricultural areas in correspondence with pelitic, alluvial silty-sandy substrates and peri-urban areas in conditions of edaphic humidity and high anthropogenic disturbance. The shrub layer is poor in species and it consists exclusively of *Rubus ulmifolius* and *Clematis vitalba*, even if locally can be also found *Laurus nobilis* and *Robinia pseudoacacia*. On the other hand, the herbaceous layer is locally rich in species and characterized by geophytes and transgressive hemicriptophytes of the *Galio-Urticetea* classes (*Galium aparine*, *Arum italicum*), *Artemisietea* (*Elymus repens*, *Poa trivialis*), *Robinietea* and terophytes of the *Stellarieta mediae* class (*Anisantha diandra*, *Avena barbata*) which highlight the conditions of high and constant anthropogenic disturbance. Characteristic and differential species of the new association are *A. altissima*, *Arum italicum*, *Elymus repens*, *Convolvulus arvensis* and *Poa trivialis*. The new association *Aro italici-Ailanthetum altissimae* that is referred to the *Lauro nobilis-Robinion pseudoacaciae* alliance (*Chelidonio-Robinietalia pseudoacaciae* order and *Robinietea* class) has floristic analogies with the *R. pseudoacacia* association *Melisso altissimae-Robinetum pseudoacaciae* widely present on alluvial plains of the Mediterranean and sub-Mediterranean region. The main differences between these two association are that the *Aro italici-Ailanthetum altissimae* is less common in the study area and has an extremely impoverished tree and shrub components. Furthermore, even if the *Robinia* forest vegetation is also found in the position of the willow groves of *Salix alba* (*Melisso altissimae-Robinietum pseudoacaciae* var. *Carex pendula*), in the investigated territories, the *A. altissima* forest vegetation is almost absent in this landscape context. This confirms what is reported in the literature on the ecology of *A. altissima* that does not tolerate prolonged conditions of soil water stagnation (e.g. Badalamenti et al. 2012).

Comparison of *A. altissima* communities in Europe and in the Mediterranean and sub–Mediterranean areas

The NMDS ordination plot (Fig. 3a) of the *A. altissima* forest coenoses here considered along with those from SE-Europe, highlights the separation into two distinct groups. The first group corresponds to the two new associations here proposed: *Asparago acutifolii–Ailanthetum altissimae* and *Aro italici-Ailanthetum altissimae* of the sub-Mediterranean and Mediterranean alliance *Lauro nobilis-Robinion pseudoacaciae*, while the second group corresponds to the *Balloto nigrae-Ailanthetum altissimae* association of the *Balloto nigrae-Robinion pseudoacaciae* alliance with a south-eastern European range. The floristic differentiation between the two groups is mainly determined by the syn-chorology. The statistically significant chorological elements (Fig. 3b) were the Mediterranean and Boreal chorotypes and the weighted presence of naturalized (archaeophytes) and invasive (neophytes) species. The Mediterranean chorotype (Fig. 3b.1) is linked to the syntaxa of the *Lauro nobilis-Robinion pseudoacaciae* alliance while the Boreal chorotype (Fig. 3b.2) and the presence of archeophyte and neophyte alien species (Fig. 3b.4) characterize the *Balloto nigrae-Ailanthetum altissimae* association of the *Balloto nigrae-Robinion pseudoacaciae* alliance. As can be seen in the Synoptic table reported in Table 2, the *Lauro nobilis-Robinion pseudoacaciae* alliance recently described for the sub-Mediterranean and Mediterranean forest communities of *Robinia pseudoacacia* confirms its floristic autonomy with respect to the analogous coenoses described for the center and SE–Europe, also for the *A. altissima* forest coenoses present at their southern limit of distribution in Europe. Even if not considered in the data processing of this work (not forest structure), the shrub communities of *A. altissima* and *Rubus ulmifolius* found in Sicily (Sciandrello et al. 2016) can also be referred to the same alliance. The *Lauro nobilis-Robinion pseudoacaciaciae* alliance could also be extended to *A. altissima* forest communities present in the Mediterranean and sub-Mediterranean areas of France. It can be done thanks to the only phytosociological relevè reported in Kowarik (1983) in which *A. altissima* communities with *Quercus ilex* of the territory of Collies (South France) shows floristic and ecological analogies with the more xerophilic elements of the *Asparago acutifolii-Ailanthetum altissimae* here proposed. At the landscape level, the sub-Mediterranean and Mediterranean *A. altissima* forest communities are mainly found in the forest landscape of the order *Quercetalia pubescentis-petraeae* with the alliances *Carpinion orientalis* and locally with those of *Quercetea ilicis* for the more xerophilic aspects. As regards the relationships with the similar sub-Mediterranean *R. pseudoacacia* of forest coenoses of the *Lauro nobilis-Robinion pseudoacaciae* alliance described above:

Table 2. Synoptic table of *A. altissima* communities in Europe. *Asparago acutifolii-Ailanthetum altissimae* ass. nova (column 1); *Aro italici-Ailanthetum altissimae* ass. nova (column 2); *Balloto nigrae-Ailanthetum altissimae* (column 3).

Life form	Chorotype	N. columns	1	2	3	Pres.
		N. rels. per column	19	8	25	
		***Asparago acutifolii-Ailanthetum altissimae* ass. nova**				
P lian	Eur./SW-Asiat.	*Hedera helix* L.	V	II	.	2
G rhiz	Medit.	*Asparagus acutifolius* L.	II	II	.	2
P caesp	S-Eur.	*Quercus pubescens* Willd.	III	.	.	1
P caesp	Medit.	*Olea europaea* L.	II	.	.	1
P scap	S-Eur./W-Asiat.	*Fraxinus ornus* L.	II	.	.	1
P caesp	Eur./W-Asiat.	*Prunus spinosa* L.	III	.	I	2
P scap	Eur./W-Asiat.	*Acer campestre* L.	III	.	I	2
		***Aro italici-Ailanthetum altissimae* ass. nova**				
G rhiz	Medit.	*Arum italicum* Miller	I	V	.	2
G rhiz	Circumbor.	*Elymus repens* (L.) Gould subsp. *repens*		III	V	2
G rhiz	S-Eur./W-Asiat.	*Convolvulus arvensis* L.		III	I	2
H caesp	Eurasiat./N-Am.	*Poa trivialis* L.	I	III	I	3
		Lauro nobilis-Robinion pseudoacaciae				
NP	Euri-Medit. Eur.	*Rubus ulmifolius* Schott	V	IV	.	2
P caesp	Medit.	*Laurus nobilis* L.	III	II	.	2
H scap	Steno-Medit.	*Melissa officinalis* subsp. *altissima*	II	III	.	2
P lian	W-Eur./Medit.	*Rubia peregrina* L.	II	I	.	2
H scap	W-Eur./Medit.	*Parietaria diffusa* M. et K.	I	III	.	2
T scap	Medit.	*Anisantha diandra* (Roth) Tutin ex Tzvelev	I	II	.	2
T scap	Medit./SW-Asiat.	*Avena barbata* Potter	I	III	.	2
H ros	Medit.	*Viola alba* Besser subsp. *dehnhardtii* (Ten.) W.Becker	I	I	.	2
P scap	Medit./SW-Asiat.	*Ficus carica* L.	I	II	.	2
P caesp	Medit.	*Rhamnus alaternus* L.	I	I	.	2
NP	Medit.	*Rosa sempervirens* L.	I	I	.	2
NP	Eur./W-Asiat.	*Ligustrum vulgare* L.	I	.	I	2
H caesp	Eur.	*Brachypodium rupestre* (Host) R. et S.	I	.	.	1
G bulb	Medit.	*Bellevalia romana* (L.) Sweet	I	.	.	1
P scap	SE-Eur./SW-Asiat.	*Juglans regia* L.	I	I	I	3
H bienn	Eurasiat./N-Afr.	*Inula conyzae* (Griess.) DC.	I	.	.	1
P scap	Medit.	*Quercus ilex* L.	I	.	.	1
G rhiz	Medit.	*Ruscus aculeatus* L.	I	.	.	1
G rhiz	Steno-Medit	*Arundo plinii* Turra	I	.	.	1
G rhiz	SW-Eur.	*Chamaeiris foetidissima* (L.) Medik.	I	.	.	1
T scap	Euri-Medit.	*Sinapis alba* L.		I	I	2
		Balloto nigrae-Ailanthetum altissimae* and *Balloto nigrae-Robinion pseudoacaciae				
T scap	Medit.	*Bromus sterilis* L.	I	II	IV	3
H caesp	Eurasiat.	*Dactylis glomerata* L.	I	.	I	2
H scap	Medit.	*Ballota nigra* L.	.	I	V	2
H bienn	S-Eur.	*Lactuca serriola* L.	.	.	II	1
H caesp	Circumbor.	*Poa angustifolia* L.	.	.	I	1
H caesp	Paleotemp.	*Arrhenatherum elatius* (L.) Presl.	.	.	I	1
H caesp	Eurosib.	*Calamagrostis epigejos* (L.) Roth	.	.	I	1
H bienn	Eurasiat.	*Cynoglossum officinale* L.	.	.	I	1
H scap	Circumbor.	*Artemisia vulgaris* L.	.	.	III	1
H bienn	Eurasiat.	*Arctium lappa* L.	.	.	II	1
H scap	A. Nat.	*Leonurus cardiaca* L.	.	.	II	1
Ch rept	Circumbor.	*Glechoma hederacea* L.	.	.	II	1
NP	N. Nat.	*Lycium barbarum* L.	.	.	I	1
Ch suffr	Sub-Cosmop.	*Artemisia absinthium* L.	.	.	II	1
T scap	Circumbor.	*Atriplex patula* L.	.	.	II	1
G rhiz	Medit.	*Sambucus ebulus* L.	.	.	II	1
H scap	Eur.	*Parietaria officinalis* L.	.	.	I	1
H scap	N. Inv.	*Solidago canadensis* L.	.	.	I	1

Table 2. Continuation.

Life form	Chorotype	N. columns	1	2	3	Pres.
		N. rels. per column	19	8	25	
		Chelidonio-Robinietalia pseudoacaciae* and *Robinietea				
P scap	N. Inv.	*Ailanthus altissima* (Mill.) Swingle	V	V	V	3
P caesp	Eur.	*Sambucus nigra* L.	III	I	I	3
T scap	Eurasiat.	Galium aparine L.	I	IV	III	3
H scap	Subcosmop.	Urtica dioica L.	II	III	III	3
P caesp	N-Am.	Robinia pseudoacacia L.	II	III	II	3
H bienn	Eur./W-Asiat.	Alliaria petiolata (M.Bieb.) Cavara & Grande	I	I	I	3
T scap	Eur.	Chaerophyllum temulum L.	II	.	I	2
H scap	Eur./W-Asiat.	Lamium maculatum L.	II	.	.	1
P lian	Eur.	Humulus lupulus L.	.	.	II	1
H scap	Eurasiat.	Geum urbanum L.	I	.	II	2
T rept	Medit.	Stellaria media (L.) Vill.	.	I	I	2
T scap	Circumbor.	Fallopia convolvulus (L.) Holub	.	I	I	2
H scap	Paleotemp.	Anthriscus sylvestris (L.) Hoffm.	.	I	I	2
H scap	Medit.	Bryonia dioica Jacq.	.	I	.	1
G rhiz	N. Inv.	Impatiens parviflora DC.	.	.	I	1
H ros	Circumbor.	Taraxacum officinale Weber gr.	.	.	I	1
H scap	Eurasiat.	Chelidonium majus L.	.	.	I	1
H scap	Eurasiat.	Alkekengi officinarum Moench	.	.	I	1
P scap	N. Inv.	Acer negundo L.	.	.	I	1
T scap	Eurasiat.	Moehringia trinervia (L.) Clairv.	.	.	I	1
T scap	A. Nat.	Anthriscus cerefolium (L.) Hoffm.	.	.	I	1
P caesp	N. Nat.	Gleditsia triacanthos L.	.	.	I	1
P caesp	A. Nat.	Prunus cerasifera Ehrh.	.	.	I	1
H scap	N. Inv.	Solidago gigantea Aiton	.	.	I	1
		Others				
P lian	Eur.	Clematis vitalba L.	IV	III	II	3
P caesp	Eur./W-Asiat.	Crataegus monogyna Jacq.	III	II	I	3
P caesp	Eur.	Cornus sanguinea L.	III	II	I	3
P caesp	Eur.	Ulmus minor Miller	III	I	I	3
P caesp	Eur.	Euonymus europaeus L.	III	I	I	3
H caesp	Eurasiat.	Brachypodium sylvaticum (Huds.) Beauv.	I	I	I	3
NP	Eurasiat.	Rubus caesius L.	I	I	II	3
H scap	Eurosib.	Stachys sylvatica L.	I	I	I	3
H caesp	Eurasiat.	Carex pendula Huds.	I	I	.	2
P lian	N. Inv.	Lonicera japonica Thunb.	I	I	.	2
G rhiz	A. Inv.	Arundo donax L.	I	I	.	2
H bienn	Eurasiat.	Silene latifolia Poiret	I	I	.	2
P scap	Eurasiat.	Populus nigra L.	I	I	.	2
NP	Eur.	Rosa canina L.	I	.	II	2
H scap	Eurosib.	Picris hieracioides L.	I	.	I	2
T scap	Subcosmop.	Torilis arvensis (Hudson) Link	I	.	I	2
H bienn	Paleotemp.	Daucus carota L.	I	.	I	2
T scap	N. Inv.	Erigeron canadensis L.	I	.	I	2
H scap	Medit.	Galium mollugo L.	I	.	I	2
H scap	Circumbor.	Clinopodium vulgare L.	I	.	I	2
H scap	Eur.	Rumex obtusifolius L.	.	II	I	2
H scap	Paleotemp.	Conium maculatum L.	.	I	II	2
P scap	Eur./W-Asiat.	Prunus avium (L.) L.	II	.	.	1
H scap	Medit.	Clinopodium nepeta (L.) Kuntze	II	.	.	1
H scap	Subcosmop.	Agrimonia eupatoria L.	.	.	II	1
H bienne	Eur.	Carduus acanthoides L.	.	.	II	1
T scap	N. Inv.	Erigeron annuus (L.) Desf.	.	.	II	1
H scap	Eurasiat.	Tanacetum vulgare L.	.	.	II	1
T scap	Sub-Cosmop.	Chenopodium album L.	.	.	II	1
		Sporadic species	35	13	98	

Rubio peregrinae-Robinietum pseudoacaciae and *Melisso altissimae-Robinietum pseudoacaciae*, it is noted that the *A. altissima* forest vegetation is less widespread in the investigated territory but it prevails over *R. pseudoacacia* forests in the more xerophilous slope conditions on dry soil (*Asparago acutifolii-Ailanthetum altissimae*) while the *R. pseudoacacia* forest vegetation is mainly distributed along the river basins, on the recent alluvial loamy-sandy terraces and in the river beds (*Melisso altissimae-Robinietum pseudoacaciae*) where the *A. altissima* forests are almost absent. The distribution of *A. altissima* and *R. pseudoacacia* forests is mainly connected to the different ecology of the two dominant invasive alien species. As reported in the literature, *A. altissima* is a thermophilous species, adapted to edaphic aridity but it is limited by low temperatures and water stagnation (Kowarik 1983; Trifilò et al. 2004; Kowarik and Saumel 2007). As can be seen from the Table 2, the impoverishment of the species of the order *Chelidonio-Robinietalia* and the *Robinietea* class in the Mediterranean area mainly concerns the *A. altissima* communities present in the most xerophilous areas with low anthropic disturbance. However, this is similar

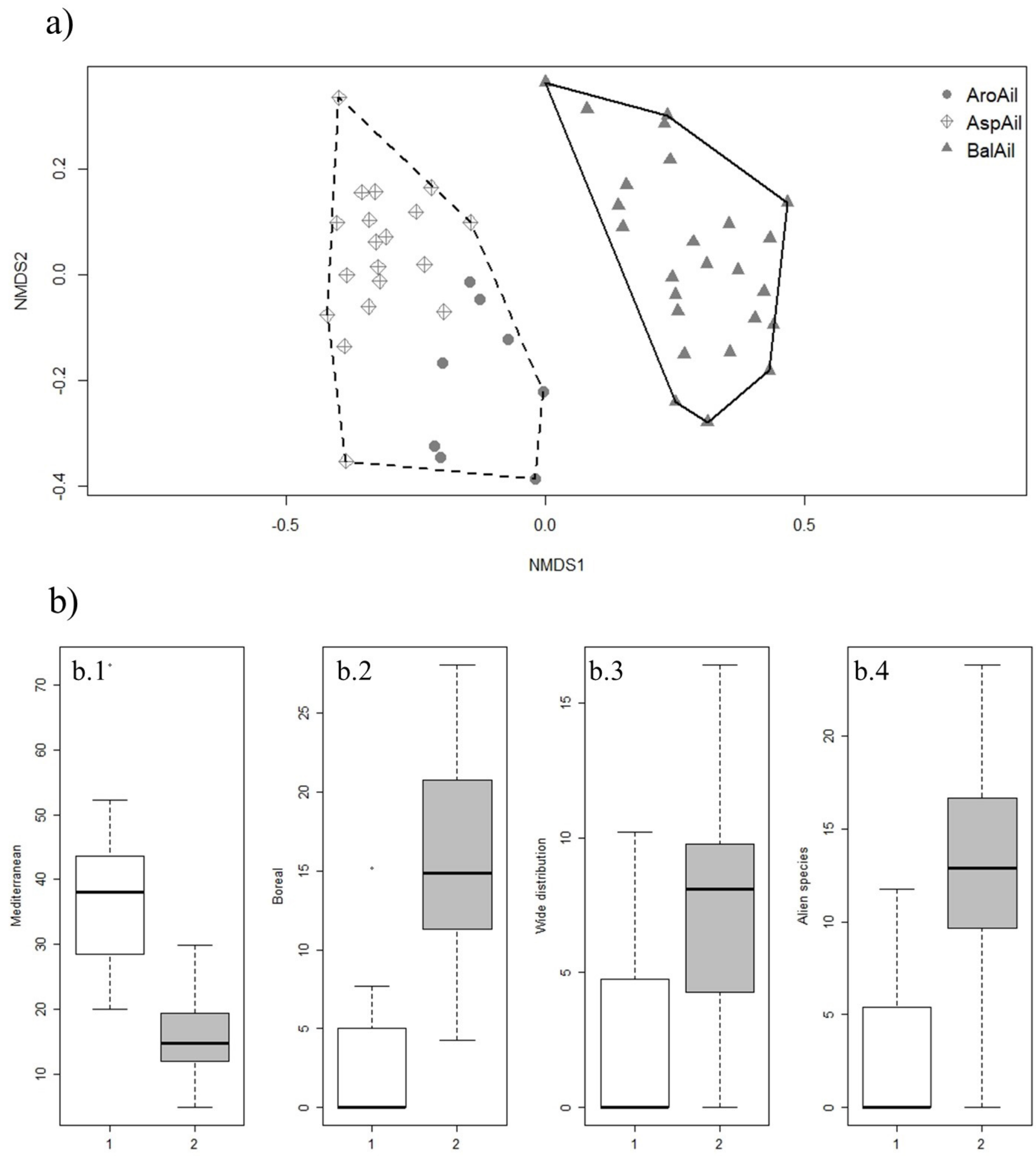

Figure 3. Ordination of the Italian and SE–European A. altissima forest associations and Box plots of chorological types. (a) NMDS scaling ordination plot (clusters are superimposed to NMDS plot) of the *A. altissima* forest coenoses here considered (dashed line) and *Balloto nigrae-Ailanthetum altissimae* from SE–Europe (continue line). Legend: Circles: *Aro italici-Ailanthetum altissimae*; Squares: *Asparago acutifolii-Ailanthetum altissimae*; Triangles: *Balloto nigrae-Ailanthetum altissimae*. (b) Comparison of the significant chorological types (weighted percentage values) between the new Italian *A. altissima* forest associations considered altogether (labelled as 1) and the *Balloto nigrae-Ailathetum altissimae* association (labelled as 2). (b.1) Mediterranean chorotype p value=2.84e–11; (b.2) Boreal chorotype p value=3.26e–11; (b.3) Wide distribution chorotype p value=1.95e–05; (b.4) Alien species (neophytes and archeopytes) p value =3.55e–10.

to what happens for the xerophilous and thermophilous communities of the order *Euphorbio cyparissiae-Robinietalia* of the class *Robinietea* shown in Vitkova and Kolbek (2010). Moreover, from an ecological point of view, the differences between *A. altissima* forests and the neighboring native forests were highlighted and proved for both *R. pseudoacacia* (Montecchiari et al. 2020a) and *A. altissima* forests (Montecchiari et al. 2020b). A great effort has been made in Europe to classify alien-dominated forest communities that previously were referred to different orders and classes. Therefore, at the current state of knowledge, the attribution to the *Robinietea* class seems to be the only way forward. Future studies in the Mediterranean area will better clarify the syntaxonomic position of the *A. altissima* communities of the *Lauro nobilis-Robinion pseudoacaciae* alliance currently belonging to the order *Chelidonio-Robinietalia* of the *Robinietea* class and also to better clarify the syntaxonomic framework of the *Robinietea* class in Europe.

Syntaxonomic scheme

ROBINIETEA Jurko ex Hadac et Sofron1980
CHELIDONIO-ROBINIETALIA PSEUDOACACIAE Jurko ex Hadac et Sofron 1980
Lauro nobilis-Robinion pseudoacaciae Allegrezza, Montecchiari, Ottaviani, Pelliccia & Tesei 2019
Asparago acutifolii-Ailanthetum altissimae ass. nova
Aro italici-Ailanthetum altissimae ass. nova

Other syntaxa quoted in the text

Agropyretea repentis Oberdorfer, Muller & Gors in Oberdorfer, Gors, Korneck, Lohmeyer, Muller, Philippi & Seibert 1967; *Ailantho altissimae-Robinietum pseudacaciae* Julve 2003; *Artemisietea vulgaris* Lohmeyer, Preising & Tüxen ex von Rochow 1951; *Balloto nigrae-Ailanthetum altissimae* Sîrbu & Oprea 2010; *Balloto nigrae-Robinion pseudoacaciae* Hadač & Sofron 1980; *Carpinion orientalis* Horvat 1958; *Chenopodietea* Br.-Bl. in Br.- Bl., Roussine & Negre 1952 p.p.; *Cratego-Prunetea* Tuxen 1962; *Euphorbio cyparissiae-Robinietalia* Vítková in Kolbek et al. 2003; *Fico-Ailanthetum altissimae* Lov. (1975) 1984 ("*Ailantho-Robinietum*" auct. adriat. pp non Gutte; Kvarner: "žiròvine"); *Fraxino excelsioris-Quercetea roboris* Gillet 1986 ex Julve 1993 class; *Galio-Urticetea* Passarge ex Kopecky´ 1969; *Lauro nobilis-Ulmion minoris* Biondi, Casavecchia, Gasparri & Pesaresi in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge & Venanzoni 2015; *Melisso altissimae-Robinetum pseudoacaciae* Allegrezza, Montecchiari, Ottaviani, Pelliccia & Tesei 2019; *Pruno avium-Carpinetalia betuli* Gillet 1986 ex Julve 1993; *Pruno spinosae-Rubion ulmifolii* O. Bolos 1954; *Pyro spinosae-Rubetalia ulmifolii* Biondi, Blasi & Casavecchia in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Vagge & Blasi 2014; *Quercetalia pubescentis-petraeae* Klika 1933; *Quercetea pubescenti–petrae* Jakucs 1960; *Quercion ilicis* Br.-Bl. ex Molinier 1934; *Querco roboris-Fagetea sylvaticae* Br.-Bl. & Vlieger in Vlieger 1937; *Rhamno-Prunetea* Rivas Goday & Borja ex Tuxen 1962; *Robinio pseudoacaciae-Ulmion minoris* Julve 1993; *Rubio peregrinae-Robinietum pseudoacaciae* Allegrezza, Montecchiari, Ottaviani, Pelliccia & Tesei 2019; *Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantò ex Rivas-Martínez, Bàscones, T.E. Dìaz, Fernàndez-Gonzàlez & Loidi 2001; *Sisymbrietea* Gutte & Hilbig 1975; *Stellarietea mediae* Tuxen, Lohmeyer & Preising ex Von Rochow 1951; *Urtico-Sambucetea* Passarge & Hofmann 1968.

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Appendixes

Appendix I - Sporadic species

Table 1 - Rel. 1 : *Allium* sp. +; rel. 2: *Daucus carota* L. +; rel. 3: *Pseudoturritis turrita* (L.) Al-Shehbaz +; *Iris germanica* L. +, *Lunaria annua* L. +, *Malus* sp. +, *Narcissus* sp. +; rel. 4: *Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz 3.4; *Colutea arborescens* L. 1.2; *Lagurus ovatus* L. +, *Tordylium apulum* L. +.2, *Verbascum sinuatum* L. +, *Erigeron canadensis* L. +; rel. 5: *Spartium junceum* L. +; *Bunium bulbocastanum* L. +, *Helleborus foetidus* L. +, *Origanum vulgare* L. +.2; rel. 6: *Artemisia campestris* L. +; *Geranium dissectum* L. +, *Umbilicus horizontalis* (Guss.) DC. +; rel. 7: *Acer pseudoplatanus* L. +; *Viburnum tinus* L. +; rel. 9: *Lonicera caprifolium* L. +; rel. 13: *Cruciata laevi-*

pes Opiz +, *Mentha spicata* L. +, *Clinopodium vulgare* L. +; rel. 14: *Ligustrum lucidum* W.T.Aiton +, *Pyrus communis* L. +, *Verbascum thapsus* L. +, *Galium mollugo* L. +; rel. 16: *Populus alba* L. +; rel. 18: *Rumex* cfr *sanguineus* +; rel. 19: *Corylus avellana* L. +; rel. 21: *Artemisia verlotiorum* Lamotte +.2, *Ligustrum japonicum* Thunb. +.

Appendix II - Relevès dates, localities and geographical coordinates (WGS84–UTM T33)

Table 1 - Rel. 1: 10/10/2019, Fossombrone (PU), Loc. San Lazzaro, 321483 E; 4839316 N; 33 T; Rel. 2: 01/10/2019, Fano (PU), Loc. Falcineto, 337141 E; 4848681 N; 33 T; rel. 3: 20/09/2019, Caldarola (MC), 349941 E; 4777643 N; 33 T; rel. 4: 12/10/2020, Marina di Massignano (AP), 405620 E; 4767840 N; 33 T; rel. 5: 24/09/2019, Serra san Quirico (AN), 338904 E; 4811611 N; 33 T; rel. 6: 19/06/2019, Castelfidardo (AN), 385604 E; 4814288 N; 33 T; rel. 7: 01/10/2019, Fano (PU), Loc. Monte Giove, 337132 E; 4853921 N; 33 T; rel. 8: 10/10/2019, Colli al Metauro (PU), Loc. Tavernelle, 329718 E; 4844106 N; 33 T; rel. 9: 10/09/2019, Fabriano (AN), Loc. san Michele, 333757 E; 4797518 N; 33 T; rel. 10: 10/09/2019, Fabriano (AN), Loc. san Michele, 334511 E; 4797268 N; 33 T; rel. 11: 20/09/2019, Belforte del Chienti (MC), 356709 E; 4779328 N; 33 T; rel. 12: 12/10/2021, Marina di Massignano (AP), 405974 E; 4768016 N; 33 T; rel. 13: 10/09/2019, Matelica (MC), Loc. Piane, 337494 E; 4796349 N; 33 T; rel. 14: 24/07/2019, Osimo (AN), Loc. Padiglione, 375354 E; 4813757 N; 33 T; rel. 15: 24/09/2019, Serra de' Conti (AN), 341462 E; 4824278 N; 33 T; rel. 16: 24/07/2019, Montefano (MC), 372499 E; 4805753 N; 33 T; rel. 17: from Fanelli 2002, Tab. 36, rel. n° 1; rel. 18: 19/06/2019, Macerata (MC), 375047 E; 4796378 N; 33 T; rel. 19: 10/09/2019, Matelica (MC), Loc. Colferraio, 339474 E; 4796335 N; 33 T; rel. 20: 18/10/2018, Castelplanio (AN), Loc. Macine-Borgo Loreto, 346354 E; 4816786 N; 33 T; rel. 21: 12/10/2019, Atri (TE), Loc. Colle Petitto, 418885 E; 4711689 N; 33 T; rel. 22: 18/10/2018, Moie (AN), 350779 E; 4818011 N; 33 T; rel. 23: 12/10/2018, Atri (TE), 418328 E; 4713782 N; 33 T; rel. 24: from Fanelli 2002, Tab. 36, rel. n° 4; rel. 25: from Fanelli 2002, Tab. 36, rel. n° 3; rel. 26: from Fanelli 2002, Tab. 36, rel. n° 7; rel. 27: from Fanelli 2002, Tab. 36, rel. n° 2.

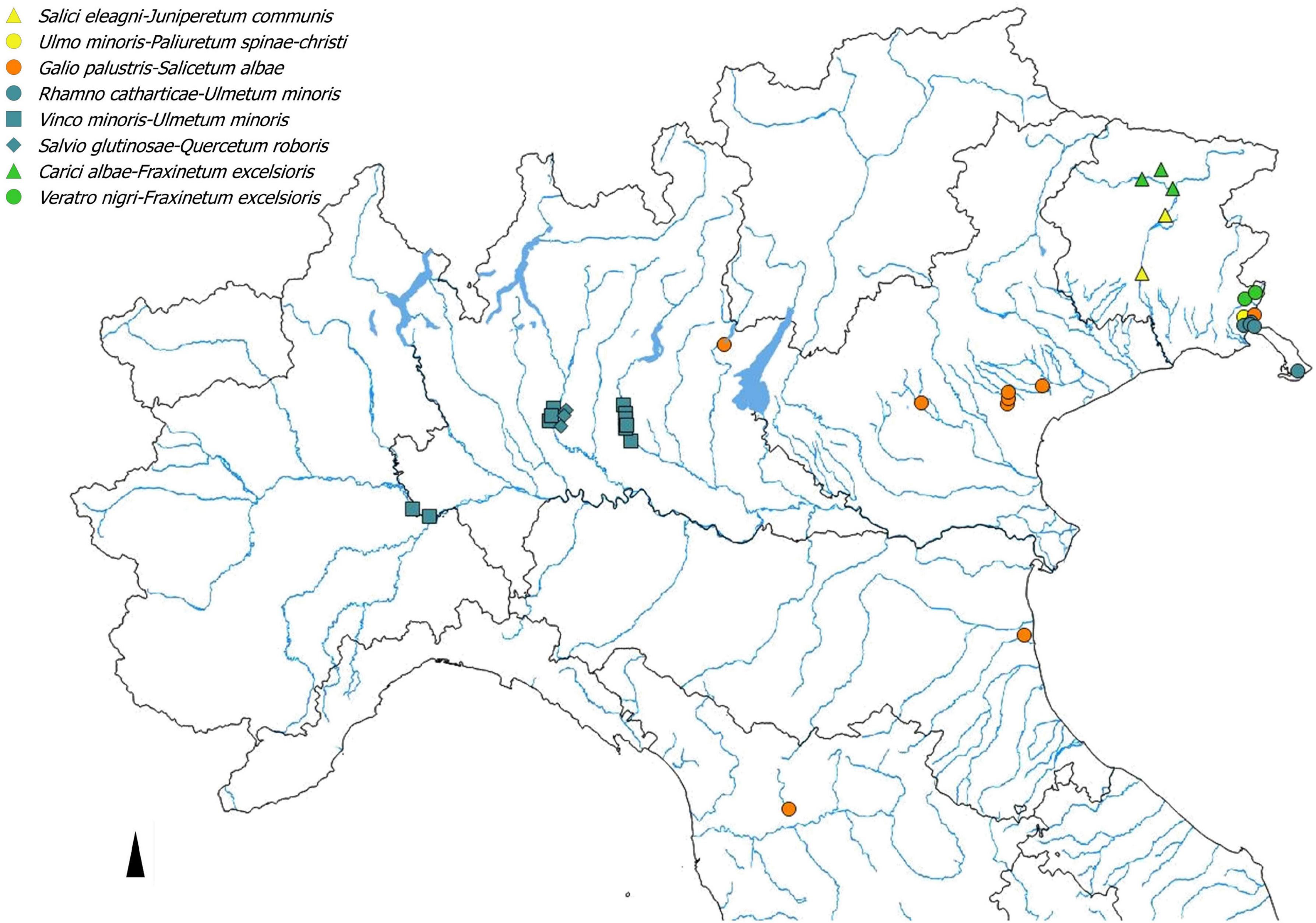

Figure S1. Distribution map of hygrophilous and meso-hygrophilous woody communities described in this paper (*Salici eleagni-Juniperetum communis*, *Ulmo minoris-Paliuretum spinae-christi*, *Rhamno catharticae-Ulmetum minoris*, *Vinco minoris-Ulmetum minoris*, *Salvio glutinosae-Quercetum roboris*, *Carici albae-Fraxinetum excelsioris*), *Galio palustris-Salicetum albae* and *Veratro nigri-Fraxinetum excelsioris* in Italy. Map created with QGIS; basic data from Geoportale Nazionale (http://www.pcn.minambiente.it/mattm/).

Table S1. Simplified synoptic table of the associations included in *Dioscoreo-Ulmion*. Species with frequency < 30 % are not reported in the table, except those with phytosociological significance. Differential species of associations are reported in bold. 1: *Rhamno catharticae-Ulmetum minoris ass. nov.* (Tab. 8 in this paper); 2: *Lamio orvalae-Ulmetum minoris* (Poldini et al. 2017); 3: *Polygonato multiflori-Quercetum roboris* (Sartori 1984; Assini 2011a); 4: *Vinco minoris-Ulmetum minoris ass. nov.* (Tab. 9 in this paper); 5: *Salvio glutinosae-Quercetum roboris ass. nov.* (orig. Tab. 1 rels. 1-7 sub "Boschi igrofili a *Populus alba*" by Cavani et al. 1981). Cl: species of *Alno glutinosae-Populetea albae*; All: species of *Dioscoreo-Ulmion minoris*; d ass: differential species of association.

	Number of column	1	2	3	4	5
	Number of relevés	8	7	42	35	7
	Species of *Rhamno catharticae-Ulmetum minoris*					
d ass	*Rhamnus cathartica* L.	85.7	28.6	.	8.6	.
Al	*Aristolochia clematitis* L.	78.6	.	14.3	2.9	28.6
Cl	*Clematis viticella* L.	71.4	.	.	.	.
d ass	*Bidens frondosa* L.	64.3	.	.	.	.
d ass	*Campanula trachelium* L. subsp. *trachelium*	64.3	.	.	.	.
Al	*Leucojum aestivum* L.	64.3	28.6	.	.	.
d ass	*Frangula alnus* Mill. subsp. *alnus*	57.1	.	2.4	8.6	.
d ass	*Clematis recta* L.	50.0	14.3	.	.	.
d ass	*Prunella vulgaris* L. subsp. *vulgaris*	50.0	.	4.8	.	.
d ass	*Galium palustre* L. s.l. (subsp. *elongatum* (C.Presl) Lange p. max p.)	42.9	.	4.8	.	.
d ass	*Ranunculus repens* L.	35.7	.	.	.	.
d ass	*Lysimachia vulgaris* L.	28.6	.	.	.	.
d ass	*Carex elata* All. subsp. *elata*	28.6	.	.	.	.
	Species of *Lamio orvalae-Ulmetum minoris*					
	Geum urbanum L.	35.7	85.7	.	2.9	.
Al	*Lamium orvala* L.	7.1	85.7	.	2.9	.
	Carex sylvatica Huds.	28.6	71.4	7.1	2.9	.
Cl	*Circaea lutetiana* L. subsp. *lutetiana*	.	57.1	7.1	2.9	.
Cl	*Arum italicum* Mill. subsp. *italicum*	7.1	57.1	.	.	.
Cl	*Alliaria petiolata* (M.Bieb.) Cavara & Grande	.	57.1	.	2.9	.
	Poa sylvicola Guss.	21.4	57.1	.	2.9	.
	Potentilla indica (Andrews) Th.Wolf	.	57.1	.	.	.
Cl	*Bryonia dioica* Jacq.	.	42.9	.	11.4	.
	Parietaria officinalis L.	.	42.9	.	14.3	.
Cl	*Carex pendula* Huds.	7.1	42.9	.	.	.
	Loncomelos pyrenaicus (L.) L.D.Hrouda	.	42.9	.	.	.
	Phalaris arundinacea L. subsp. *arundinacea*	.	42.9	.	.	.
	Allium ursinum L.	.	42.9	.	.	.
	Anemonoides ranunculoides (L.) Holub	.	42.9	.	2.9	.
	Species of *Polygonato multiflori-Quercetum roboris*					
	Convallaria majalis L.	.	.	69.0	.	.
	Cornus mas L.	.	.	57.1	2.9	.
Al	*Asparagus tenuifolius* Lam.	21.4	14.3	45.2	.	14.3
	Prunus padus L.	.	14.3	45.2	.	.
	Malus sylvestris (L.) Mill. (incl. *M. domestica* (Borkh.) Borkh.)	.	.	42.9	.	14.3
	Galeopsis pubescens Besser	.	.	42.9	5.7	.
	Melica nutans L.	.	.	42.9	.	.
	Species of *Vinco minoris-Quercetum roboris*					
Al	*Vinca minor* L.	7.1	14.3	16.7	51.4	14.3
	Species of *Salvio glutinosae-Quercetum roboris*					
Cl	*Populus alba* L.	.	14.3	26.2	5.7	100.0
	Neottia ovata (L.) Bluff & Fingerh.	.	14.3	.	2.9	71.4
	Salvia glutinosa L.	.	.	11.9	22.9	71.4
	Aegonychon purpurocaeruleum (L.) Holub	.	.	.	.	57.1
	Species of *Dioscoreo-Ulmion*					
	Dioscorea communis (L.) Caddick & Wilkin	14.3	42.9	38.1	65.7	71.4
	Lonicera caprifolium L.	7.1	28.6	19.0	25.7	.
	Primula vulgaris Huds. subsp. *vulgaris*	.	57.1	.	.	**85.7**
	Species of *Alno glutinosae-Populetea albae*					
	Ulmus minor Mill. subsp. *minor*	100.0	100.0	59.5	100.0	85.7
	Populus nigra L.	85.7	14.3	28.6	37.1	51.1
	Rubus caesius L.	64.3	85.7	52.4	91.4	42.9
	Quercus robur L. subsp. *robur*	14.3	71.4	100.0	88.6	100.0
	Humulus lupulus L.	42.9	42.9	.	5.7	14.3

Table S1. Continuation.

Number of column	1	2	3	4	5
Number of relevés	8	7	42	35	7
Ficaria verna Huds. s.l.	21.4	**42.9**	.	5.7	14.3
Brachypodium sylvaticum (Huds.) P.Beauv.	71.4	**100.0**	21.4	11.4	.
Urtica dioica L. s.l.	21.4	28.6	9.5	8.6	.
Viburnum opulus L.	28.6	.	11.9	11.4	.
Fraxinus angustifolia Vahl subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso	**92.9**	71.4	.	.	.
Other species					
Crataegus monogyna Jacq.	100.0	71.4	81.0	88.6	57.1
Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó and subsp. *australis* (C.A.Mey.) Jáv.)	92.9	57.1	42.9	100.0	42.9
Ligustrum vulgare L.	64.3	71.4	28.6	91.4	57.1
Euonymus europaeus L.	57.1	85.7	71.4	17.1	14.3
Hedera helix L. subsp. *helix*	42.9	71.4	45.2	57.1	57.1
Clematis vitalba L.	21.4	14.3	4.8	48.6	28.6
Robinia pseudoacacia L.	14.3	57.1	33.3	62.9	42.9
Limniris pseudacorus (L.) Fuss	28.6	.	.	11.4	14.3
Acer campestre L.	21.4	**100.0**	26.2	14.3	.
Galium aparine L.	7.1	**71.4**	2.4	22.9	.
Glechoma hederacea L.	21.4	**42.9**	19.0	17.1	.
Prunus spinosa L. subsp. *spinosa*	28.6	14.3	2.4	14.3	.
Equisetum arvense L.	28.6	14.3	.	8.6	.
Fraxinus ornus L. subsp. *ornus*	28.6	14.3	.	8.6	.
Viola reichenbachiana Jord. ex Boreau (incl. *V. riviniana* Rchb. subsp. *riviniana*)	57.1	57.1	21.4	.	.
Ruscus aculeatus L.	**50.0**	28.6	.	.	.
Sambucus nigra L.	.	**100.0**	9.5	37.1	28.6
Corylus avellana L.	.	57.1	97.6	37.1	85.7
Alnus glutinosa (L.) Gaertn.	.	28.6	14.3	17.1	14.3
Symphytum tuberosum L. subsp. *angustifolium* (A.Kern.) Nyman	.	28.6	9.5	.	42.9
Paris quadrifolia L.	.	14.3	9.5	.	**28.6**
Polygonatum multiflorum (L.) All.	.	71.4	64.3	.	57.1
Anemonoides nemorosa (L.) Holub	.	28.6	28.6	5.7	28.6
Aegopodium podagraria L.	.	28.6	.	20.0	.
Asarum europaeum L. s.l. (incl. subsp. *caucasicum* (Duch.) Soó)	.	.	2.4	34.3	**71.4**
Symphytum officinale L.	.	.	19.0	17.1	**57.1**
Viburnum lantana L.	.	.	2.4	51.4	57.1
Viola canina L. subsp. *canina*	.	.	4.8	22.9	42.9
Ornithogalum divergens Boreau	14.3	.	.	2.9	28.6
Isopyrum thalictroides L.	.	.	.	.	42.9

Table S2. *Amorpho fruticosae-Salicetum albae*, *populetosum nigrae* subass. nov. (rels 1-24), *urticetosum diocae* subass. nov. (rels 25-87). Relevés are arranged according to cluster analysis (cover data, Similarity ratio, UPGMA). Cl: species of *Salicetea purpureae*; All: species of *Salicion albae*; A: alien species.

	Relevé number	1*	2	3	4	5	6	7	8**	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	No. of species (incl. sporadic species)	19	12	13	14	14	13	15	21	15	34	20	18	18	17	29	18	11	17	11	19	12	7	9	7	27	20	20	11	27	24	15	13	15	14	24	19	17	11	14	17	15	16
		1 *populetosum nigrae*																								2 *urticetosum dioicae*																	
		1a var. with *Rubus caesius*														**1b** var. with *Lythrum salicaria*										**2a** var. with *Sambucus nigra* and *Cucubalus baccifer*																	
	Species of association																																										
Cl, All	*Salix alba* L. (incl. *S. ×rubens* Schrank)	3	4	1	2	4	3	3	2	3	1	2	2	4	2	1	5	5	5	3	2	3	4	5	4	2	3	2	4	4	4	5	4	3	4	2	3	4	3	3	3	3	3
A	*Amorpha fruticosa* L.	2	3	2	1	2	3	3	2	2	2	1	2	+	.	1	.	.	1	.	.	+	3	1	4	1	1	.	2	2	1	1	.	4	+	.	.	.	.	.	.	.	.
A	*Solidago gigantea* Aiton	2	+	2	+	2	+	1	2	1	1	2	2	.	1	+	.	.	+	.	.	.	.	.	.	3	2	1	.	1	2	1	1	2	2	2	1	+	.	.	1	.	3
A	*Helianthus tuberosus* L.	.	.	+	.	+	.	.	3	.	1	1	+	+	3	.	.	.	+	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	+	+	1	.	.	.	.	.
	Species of subass. *populetosum nigrae*																																										
Cl, All	*Populus nigra* L. (incl. *P. ×canadensis* Moench)	1	.	4	1	1	1	+	3	1	1	2	4	+	2	2	+	+	2	+	2	1	.	1	4	4	2	.	.	.	2	.	.	.	2	3	.	.	.	1	1	.	1
	Salix triandra L. subsp. *triandra*	.	1	1	3	.	1	.	.	.	2	1	+	2	.	.	.	.	+	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Salix purpurea L. s.l.	.	.	1	1	.	.	1	.	.	.	.	1	.	.	.	.	.	+	.	1	1	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
	Salix eleagnos Scop. (incl. *S. viminalis* L.)	.	.	.	.	.	.	.	.	.	2	1	1	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	var. with *Rubus caesius*																																										
	Equisetum arvense L.	2	2	4	2	+	3	3	2	3	+	+	.	.	.	.	.	.	.	+	1	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
A	*Ambrosia artemisiifolia* L.	1	.	+	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Agrostis gigantea Roth subsp. *gigantea*	.	.	.	.	.	1	.	.	.	1	2	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Calamagrostis pseudophragmites (Haller f.) Koeler subsp. *pseudophragmites*	.	.	.	.	.	.	+	.	.	2	2	2	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plantago lanceolata L.	.	.	.	.	.	.	.	.	+	+	+	.	r	.	+	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	var. with *Lythrum salicaria*																																										
	Agrostis stolonifera L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	+	+	.	1	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
	Lythrum salicaria L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	1	+	+	+	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	1	+	+	+
	Alnus glutinosa (L.) Gaertn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	2	1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
	Epilobium hirsutum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Equisetum ramosissimum Desf.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Species of subass. *urticetosum dioicae*																																										
	Urtica dioica L. s.l.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	1	+	2	1	5	3	+	5	2	3	2	+	.	1	+	3
	Phalaris arundinacea L. subsp. *arundinacea*	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	3	1	.	.	.	.	+	+	2	2	4	4
	Poa trivialis L.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2	+	+	3	1	.	.	.	.	.	.	.	.	.
	Convolvulus sepium L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	+	1	.	+	.	.	.	+	.	.	.	1	.	+
	Limniris pseudacorus (L.) Fuss	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.
	var. with *Sambucus nigra* **and** *Cucubalus baccifer*																																										
	Humulus lupulus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	1	2	1	2	1	1	2	1	1	2	.	+	+	1	+	+
	Galium aparine L.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	+	1	2	2	1	1	.	1	.	.	.	.	.	.	.
Cl	*Sambucus nigra* L.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	1	+	+	+	1	.	.	.	.
	Parietaria officinalis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	4	+	+	.	.	.	.	.
	Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó)	+	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Cl	*Brachypodium sylvaticum* (Huds.) P.Beauv.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	2	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.
	Clematis vitalba L.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Cl	*Silene baccifera* (L.) Durande	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	2	.	.	+	.	.	.	.	.	+
Cl	*Bryonia dioica* Jacq.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	+	+	.	+	.	.	.	.	.
	Diff. species of subass. 1 and var. 1a, 1b, 2a																																										
	Eupatorium cannabinum L. subsp. *cannabinum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	1	.	.	+	.	.	1	1	.	.	.	1	+	.	.	.	.	.	.	.
	Dioscorea communis (L.) Caddick & Wilkin	.	.	.	+	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
	Lysimachia vulgaris L.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.
	Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	1	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.
	var. with *Bidens frondosa* **and** *Persicaria dubia*																																										
A	*Sicyos angulatus* L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
A	*Bidens frondosa* L.	1	+	.	.	.	.	.	.	.	+	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.
	Rumex conglomeratus Murray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
	Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Chenopodium album L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
A	*Humulus japonicus* Siebold & Zucc.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	*Apios americana* Medik.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	4	.
	Ranunculus repens L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plantago major L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lycopus europaeus L.	.	.	.	.	+	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
A	*Erigeron canadensis* L.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Rorippa sylvestris (L.) Besser subsp. *sylvestris*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Cardamine hirsuta L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Ranunculus sardous Crantz	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mentha aquatica L. subsp. *aquatica*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Atriplex patula L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Solanum nigrum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Stellaria media (L.) Vill. subsp. *media*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
	Persicaria maculosa Gray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Silene latifolia Poir.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
	Rorippa amphibia (L.) Besser	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Equisetum sylvaticum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Capsella bursa-pastoris (L.) Medik. subsp. *bursa-pastoris*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Veronica arvensis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Other alien species																																										
	Xanthium italicum Moretti	+	.	.	.	.	.	.	.	.	2	+	+	+	+	2	.	1	+	.	1	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
	Artemisia verlotiorum Lamotte	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
	Morus alba L. (incl. *M. nigra* L.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
	Erigeron annuus (L.) Desf.	.	+	.	.	1	+	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Artemisia annua L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Oenothera biennis L.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Acer negundo L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+
	Amaranthus hybridus (aggr.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Robinia pseudoacacia L.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Prunus persica (L.) Batsch	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.

Table S2. Continuation.

	Relevé number	43	44	45	46	47	48	49**	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	
	No. of species (incl. sporadic species)	18	8	15	20	18	21	20	28	9	12	20	15	21	17	17	13	17	14	15	16	16	11	9	17	12	12	16	26	25	29	20	16	29	26	16	16	30	28	26	12	25	16	13	8	16	
		2 urticetosum dioicae																																													
		2b var. with *Bidens frondosa* and *Persicaria dubia*																																													
	Species of association																																														**Fr.**
Cl, All	*Salix alba* L. (incl. *S. ×rubens* Schrank)	5	3	2	3	3	3	3	3	2	3	3	3	4	4	2	2	4	3	3	3	3	3	3	2	4	3	3	5	4	4	3	3	4	2	3	3	2	3	4	3	4	3	2	3	4	100,0
A	*Amorpha fruticosa* L.	+	.	.	.	+	+	+	2	+	2	+	+	1	1	+	1	2	1	1	2	3	1	2	1	2	1	+	+	1	+	1	2	+	.	.	+	1	+	.	.	1	.	.	.	.	70,1
A	*Solidago gigantea* Aiton	+	1	2	+	.	.	+	2	.	.	+	+	+	2	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	+	.	.	+	+	.	.	1	55,2
A	*Helianthus tuberosus* L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	21,8
	Species of subass. *populetosum nigrae*																																														
Cl, All	*Populus nigra* L. (incl. *P. ×canadensis* Moench)	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	.	1	40,2
	Salix triandra L. subsp. *triandra*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	16,1
	Salix purpurea L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	11,5
	Salix eleagnos Scop. (incl. *S. viminalis* L.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	var. with *Rubus caesius*																																														
	Equisetum arvense L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	27,6
A	*Ambrosia artemisiifolia* L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	Agrostis gigantea Roth subsp. *gigantea*	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6,9
	Calamagrostis pseudophragmites (Haller f.) Koeler subsp. *pseudophragmites*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6,9
	Plantago lanceolata L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8,0
	var. with *Lythrum salicaria*																																														
	Agrostis stolonifera L. s.l.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	3	+	2	.	.	.	.	.	+	.	.	.	.	19,5
	Lythrum salicaria L.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18,4
	Alnus glutinosa (L.) Gaertn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	Epilobium hirsutum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3,4
	Equisetum ramosissimum Desf.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3,4
	Species of subass. *urticetosum dioicae*																																														
	Urtica dioica L. s.l.	3	1	4	3	+	1	4	1	.	.	3	2	+	3	.	+	1	2	2	1	.	2	3	+	1	.	2	+	2	2	1	2	+	+	.	4	+	+	+	1	2	.	.	3	1	64,4
	Phalaris arundinacea L. subsp. *arundinacea*	2	1	2	+	3	2	+	3	2	1	2	+	+	1	+	1	5	5	4	1	4	4	5	2	3	4	.	+	+	+	3	5	3	+	.	.	2	1	.	3	1	.	+	.	1	59,8
	Poa trivialis L.	1	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	+	+	+	+	+	.	+	.	4	24,1
	Convolvulus sepium L.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	+	+	.	2	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19,5
	Limniris pseudacorus (L.) Fuss	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	.	+	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12,6
	var. with *Sambucus nigra* **and** *Cucubalus baccifer*																																														
	Humulus lupulus L.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	1	+	1	4	.	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	31,0
	Galium aparine L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	17,2
Cl	*Sambucus nigra* L.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11,5
	Parietaria officinalis L.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	11,5
	Cornus sanguinea L. s.l. (incl. subsp. *hungarica* (Kárpáti) Soó)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	11,5
Cl	*Brachypodium sylvaticum* (Huds.) P.Beauv.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8,0
	Clematis vitalba L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6,9
Cl	*Silene baccifera* (L.) Durande	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6,9
Cl	*Bryonia dioica* Jacq.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	Diff. species of subass. 1 and var. 1a, 1b, 2a																																														
	Eupatorium cannabinum L. subsp. *cannabinum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10,3
	Dioscorea communis (L.) Caddick & Wilkin	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	Lysimachia vulgaris L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5,7
	var. with *Bidens frondosa* **and** *Persicaria dubia*																																														
A	*Sicyos angulatus* L.	+	3	1	2	.	+	3	1	+	1	3	1	2	2	4	5	1	1	1	+	1	4	.	+	5	+	1	+	5	2	1	1	1	.	+	3	+	1	+	3	+	.	.	.	.	44,8
A	*Bidens frondosa* L.	.	.	.	+	1	1	.	.	.	.	+	.	3	2	1	+	1	+	1	+	2	+	.	1	2	2	2	2	4	4	5	2	1	+	1	+	1	1	2	1	.	+	1	.	.	44,8
	Rumex conglomeratus Murray	2	.	+	+	.	+	+	.	.	.	1	+	+	1	.	.	.	.	.	+	.	.	.	+	.	+	.	.	.	.	.	.	.	.	1	+	+	+	+	.	+	+	+	.	.	24,1
	Persicaria dubia (Stein.) Fourr.	1	.	.	+	.	.	+	.	.	.	.	4	1	1	.	1	+	1	+	+	+	.	.	.	.	.	1	.	2	+	+	+	3	+	.	.	.	.	.	.	.	.	.	.	.	23,0
	Chenopodium album L. s.l.	+	+	+	.	2	.	.	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	1	.	.	.	.	.	.	+	+	+	.	.	+	+	.	.	19,5
A	*Humulus japonicus* Siebold & Zucc.	2	4	+	+	+	.	.	1	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	1	.	+	+	.	.	.	.	.	.	.	5	.	17,2
A	*Apios americana* Medik.	+	.	.	.	+	+	.	.	2	+	.	.	.	.	.	.	2	+	.	+	.	1	1	.	.	.	1	.	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	17,2
	Ranunculus repens L.	.	.	.	+	.	+	.	.	.	.	1	+	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	10,3
	Plantago major L.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	5,7
	Lycopus europaeus L.	.	.	.	.	.	+	.	.	.	.	+	.	1	1	2	+	+	+	+	.	+	.	.	+	.	1	.	.	+	+	1	+	+	.	.	.	.	+	+	.	+	+	+	.	.	32,2
A	*Erigeron canadensis* L.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	+	.	+	+	1	+	1	+	+	+	.	.	.	.	.	.	.	+	+	.	.	19,5
	Rorippa sylvestris (L.) Besser subsp. *sylvestris*	.	.	.	.	.	.	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	5,7
	Cardamine hirsuta L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	.	.	.	.	.	.	5,7
	Ranunculus sardous Crantz	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	+	.	.	.	.	.	5,7
	Mentha aquatica L. subsp. *aquatica*	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	1	9,2
	Atriplex patula L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	6,9
	Solanum nigrum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	9,2
	Stellaria media (L.) Vill. subsp. *media*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	+	6,9
	Persicaria maculosa Gray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	+	1	.	.	.	.	.	.	5,7
	Silene latifolia Poir.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	4,6
	Rorippa amphibia (L.) Besser	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	3,4
	Equisetum sylvaticum L.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	2	.	.	.	.	.	.	.	.	.	4,6
	Capsella bursa-pastoris (L.) Medik. subsp. *bursa-pastoris*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	4,6
	Veronica arvensis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	4,6
	Other alien species																																														
	Xanthium italicum Moretti	+	.	.	.	.	+	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	.	.	.	.	.	.	.	2	+	.	.	27,6
	Artemisia verlotiorum Lamotte	.	.	+	2	+	1	+	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	16,1
	Morus alba L. (incl. *M. nigra* L.)	.	.	.	.	+	.	.	.	.	+	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	2	.	13,8
	Erigeron annuus (L.) Desf.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	+	+	+	+	.	+	.	.	.	.	1	.	.	.	.	.	.	14,9
	Artemisia annua L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	.	.	+	+	+	.	.	+	+	.	.	14,9
	Oenothera biennis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	+	.	.	+	.	+	.	.	.	.	.	.	11,5
	Acer negundo L.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	1	.	.	.	.	.	.	.	.	.	.	10,3
	Amaranthus hybridus (aggr.)	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	+	.	.	.	+	.	.	.	.	.	.	1	.	.	.	8,0
	Robinia pseudoacacia L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	5,7
	Prunus persica (L.) Batsch	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	5,7

Table S2. Continuation.

	Relevé number	1*	2	3	4	5	6	7	8**	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	No. of species (incl. sporadic species)	19	12	13	14	14	13	15	21	15	34	20	18	18	17	29	18	11	17	11	19	12	7	9	7	27	20	20	11	27	24	15	13	15	14	24	19	17	11	14	17	15	16
		1 *populetosum nigrae*																								2 *urticetosum dioicae*																	
		1a var. with *Rubus caesius*														**1b** var. with *Lythrum salicaria*										**2a** var. with *Sambucus nigra* and *Cucubalus baccifer*																	
	Other species																																										
Cl	*Rubus caesius* L.	2	2	2	1	+	1	2	2	3	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	3	5	3	2	3	3	4	.	1	+	.	.	1	3	2	3
	Artemisia vulgaris L.	.	.	.	1	.	+	.	1	.	+	+	.	.	2	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
	Persicaria hydropiper (L.) Delarbre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	2	.	1	3	5	.	.	.	.
	Elymus repens (L.) Gould subsp. *repens*	.	.	1	+	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Phragmites australis (Cav.) Trin. ex Steud. s.l.	.	.	.	.	.	.	2	+	.	.	.	.	.	+	+	1	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	+
	Daucus carota L. s.l.	.	.	.	.	+	+	.	.	.	1	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Echinochloa crus-galli (L.) P.Beauv. subsp. *crus-galli*	.	.	.	.	.	.	.	2	.	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Poa palustris L. subsp. *palustris*	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	2	+	1	1
	Carex acutiformis Ehrh.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	4	2	+	.
	Galium palustre L. (incl. subsp. *elongatum* (C.Presl) Lange)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	+	.
	Stachys palustris L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
	Persicaria lapathifolia (L.) Delarbre s.l.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Saponaria officinalis L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
	Dactylis glomerata L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
	Typha latifolia L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table S2. Continuation.

	RA103:AV165elevé number	43	44	45	46	47	48	49**	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	
	No. of species (incl. sporadic species)	18	8	15	20	18	21	20	28	9	12	20	15	21	17	17	13	17	14	15	16	16	11	9	17	12	12	16	26	25	29	20	16	29	26	16	16	30	28	26	12	25	16	13	8	16	
		2 urticetosum dioicae																																													
		2b var. with *Bidens frondosa* and *Persicaria dubia*																																													
Other species																																															
Cl	*Rubus caesius* L.	3	3	+	1	3	4	2	2	+	4	2	2	.	.	.	+	2	2	1	5	2	3	3	+	1	4	+	+	.	+	1	1	1	.	.	+	+	1	.	+	+	.	.	1	.	69,0
	Artemisia vulgaris L.	.	.	.	.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+	+	+	+	+	.	.	.	.	2	.	25,3
	Persicaria hydropiper (L.) Delarbre	.	.	.	.	.	2	.	+	5	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	+	+	1	.	.	.	.	.	.	.	4	2	.	1	+	+	.	.	1	.	.	25,3
	Elymus repens (L.) Gould subsp. *repens*	+	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	12,6
	Phragmites australis (Cav.) Trin. ex Steud. s.l.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12,6
	Daucus carota L. s.l.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	13,8
	Echinochloa crus-galli (L.) P.Beauv. subsp. *crus-galli*	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	1	+	.	.	.	.	.	.	.	1	.	.	.	13,8
	Poa palustris L. subsp. *palustris*	.	.	1	.	.	2	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	14,9
	Carex acutiformis Ehrh.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	2	.	+	1	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13,8
	Galium palustre L. (incl. subsp. *elongatum* (C.Presl) Lange)	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	9,2
	Stachys palustris L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	9,2
	Persicaria lapathifolia (L.) Delarbre s.l.	.	.	.	4	2	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10,3
	Saponaria officinalis L.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2	.	6,9
	Dactylis glomerata L. s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	5,7
	Typha latifolia L.	.	.	.	.	.	.	.	.	2	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4,6

Table S1. *Potamogetono pectinati-Myriophylletum spicati*, *Persicaria amphibia community*, *Myriophylletum verticillati*, *Nymphaeetum albae*.

Relevé number	1	2	3	4	5	6	7	8	9	10	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	9	219	10	11	12	7	8	4	5	6		
Elevation (m a.s.l.)	756	756	756	756	756	756	756	756	756	756		
Aspect	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100	100	100	100		
Area (m²)	10	10	10	10	10	10	10	8	8	8		
Locality	PC	PC	PC	PC	PC	PC	PC	PC	PC	PC		
Char. species of *Potamogetono pectinati-Myriophylletum spicati* association												
Myriophyllum spicatum L.	5	5	.	.	.	.	.	.	.	.	2	20
Species of *Persicaria amphibia* community												
Persicaria amphibia (L.) Delarbre	.	.	4	4	3	1	.	+	.	.	5	50
Char. species of *Myriophylletum verticillati* association												
Myriophyllum verticillatum L.	+	+	2	+	.	5	5	3	1	+	9	90
Char. species of *Nymphaeetum albae* association												
Nymphaea alba L.	.	.	.	.	.	.	.	5	5	5	3	30
Other species												
Mentha aquatica L. subsp. *aquatica*	.	.	+	.	.	+	+	.	.	.	3	30
Rorippa amphibia (L.) Besser	.	.	.	.	.	+	.	+	.	.	2	20
Carex acuta L.	.	.	.	.	+	.	.	.	.	.	1	10
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	.	+	.	.	.	.	.	1	10

Table S2. *Callitriche stagnalis* community.

Relevé number	1	2	3	4	5	6	7	8	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	1	14	2	15	3	16	231	233		
Elevation (m a.s.l.)	756	756	756	756	780	780	752	752		
Aspect	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100	100		
Area (m²)	4	2	4	3	4	2	8	5		
Locality	PC	PC	PC	PC	Ar	Ar	Co	Co		
Species of *Callitriche stagnalis* community										
Callitriche stagnalis Scop.	5	5	5	5	5	5	5	5	8	100
Char. species of *Ranunculion aquatilis* alliance										
Ranunculus trichophyllus Chaix	.	+	.	+	.	.	.	.	2	25
Ingressive species from *Phragmito-Magnocaricetea* class										
Nasturtium officinale R.Br.	+	+	+	+	.	.	.	.	4	50
Mentha aquatica L. subsp. *aquatica*	+	+	.	.	+	+	.	.	4	50
Berula erecta (Huds.) Coville	+	+	.	.	.	.	.	.	2	25
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	r	r	.	.	.	.	.	.	2	25
Helosciadium nodiflorum (L.) W.D.J.Koch subsp. *nodiflorum*	.	.	+	+	.	.	.	.	2	25
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	.	.	.	.	+	+	.	.	2	25

Table S3. *Potamogetono crispi-Ranunculetum trichophylli*, *Glycerietum notatae*.

Relevé number	1	2	3	4	5	6	7	8	9	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	54	232	19	17	18	72	71	73	74		
Elevation (m a.s.l.)	780	752	780	780	780	780	756	779	779		
Aspect	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100	90	90		
Area (m²)	25	10	3	8	15	3	6	8	8		
Locality	Ar	Co	Ar	P	P	Ar	PC	Ar	Ar		
Char. species of *Potamogetono crispi-Ranunculetum trichophylli* and *Ranunculion aquatilis* alliance											
Ranunculus trichophyllus Chaix	5	5	5	5	5	4	1	.	.	7	78
Callitriche stagnalis Scop.	.	.	+	.	.	.	.	.	.	1	11
Char. species of *Glycerietum notatae* association and *Glycerio-Sparganion* alliance											
Glyceria notata Chevall.	.	.	+	.	.	4	4	5	4	5	56
Myosotis scorpioides L. subsp. *scorpioides*	1	.	+	.	.	+	+	.	.	4	44
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	.	+	+	1	1	.	1	.	.	5	56
Nasturtium officinale R.Br. subsp. *officinale*	.	.	+	.	.	.	+	.	.	2	22
Char. species of *Phragmito-Magnocaricetea* class											
Mentha aquatica L. subsp. *aquatica*	1	.	+	.	.	2	2	.	.	4	44
Rorippa amphibia (L.) Besser	+	.	+	.	.	.	.	.	.	2	22
Alisma plantago-aquatica L.	.	1	.	.	.	.	+	.	.	2	22
Species of *Potentillion anserinae* and higher syntaxa											
Ranunculus repens L.	.	.	.	.	.	.	+	+	+	3	33
Carex otrubae Podp.	+	.	.	.	.	.	.	+	.	2	22
Gratiola officinalis L.	1	.	.	.	.	.	.	.	+	2	22

Table S4. *Beruletum erectae*, *Rorippo ancipitis-Catabrosetum aquaticae*, *Veronica anagallis-aquatica* community, *Nasturtietum officinalis*, *Helosciadietum nodiflori*.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	228	229	230	84	79	83	85	78	82	77	75	86	13	80	76	81		
Elevation (m a.s.l.)	752	752	752	800	795	795	800	756	756	756	756	800	756	756	756	756		
Aspect	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	90	90	100	100	100	100	95	95	100	100	80	100		
Area (m²)	10	15	20	20	5	5	20	6	6	10	10	20	10	10	10	10		
Locality	Co	Co	Co	Cc	R	R	Cc	PC	PC	PC	PC	Cc	PC	PC	PC	PC		
Char. species of *Beruletum erectae* association																		
Berula erecta (Huds.) Coville	5	5	5	.	.	.	.	.	.	.	.	.	.	.	2	2	5	31
Char. species of *Rorippo ancipitis-Catabrosetum aquaticae* association																		
Catabrosa aquatica (L.) P.Beauv.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	1	6
Species of *Veronica anagallis-aquatica* community																		
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	1	+	2	3	4	4	5	5	5	.	1	2	4	4	+	+	15	94
Char. species of *Nasturtietum officinalis* association																		
Nasturtium officinale R.Br.	2	.	.	.	.	.	3	1	1	5	5	5	2	2	4	1	11	69
Glyceria notata Chevall.	+	+	.	+	.	.	.	.	.	.	.	.	+	+	+	+	7	44
Char. species of *Helosciadietum nodiflori* association																		
Helosciadium nodiflorum (L.) W.D.J.Koch subsp. *nodiflorum*	.	.	.	2	.	.	.	.	.	.	.	.	4	4	4	4	5	31
Species of *Phragmito-Magnocaricetea* class																		
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	.	.	.	.	+	+	.	+	.	.	.	1	+	5	31
Myosotis scorpioides L. subsp. *scorpioides*	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	4	25
Mentha aquatica L. subsp. *aquatica*	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	3	19
Alisma plantago-aquatica L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	6
Ingressive species from *Molinio-Arrhenatheretea* class																		
Ranunculus repens L.	.	.	.	2	2	2	.	.	.	.	1	+	.	.	+	.	6	38
Holcus lanatus L. subsp. *lanatus*	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	2	13
Agrostis stolonifera L. subsp. *stolonifera*	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	2	13
Poa pratensis L. subsp. *pratensis*	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	6
Dactylis glomerata L. subsp. *glomerata*	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	6
Other species																		
Equisetum palustre L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	2	13
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	2	13
Epilobium hirsutum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	6
Petasites hybridus (L.) G.Gaertn., B.Mey. & Scherb. subsp. *hybridus*	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	6
Cerastium ligusticum Viv.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	6

Table S5. *Eleocharitetum palustris*.

Relevé number	1	2	3	4	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	68	69	67	70		
Elevation (m a.s.l.)	756	794	780	780		
Aspect	-	-	-	-		
Slope angle (°)	0	0	0	0		
Total cover (%)	100	100	100	100		
Area (m²)	1	8	1	1		
Locality	PC	R	Ar	Ar		
Char. species of *Eleocharitetum palustris* association and higher syntaxa						
Eleocharis palustris (L.) Roem. et Schult. subsp. *palustris*	4	5	5	5	4	100
Phalaris arundinacea L. subsp. *arundinacea*	.	1	.	.	1	25
Mentha aquatica L. subsp. *aquatica*	.	.	.	+	1	25
Other species						
Trifolium repens L.	1	.	.	.	1	25
Ranunculus sardous Crantz	+	.	.	.	1	25
Ranunculus repens L.	+	.	1	.	2	50
Thalictrum lucidum L.	.	+	.	.	1	25
Potentilla reptans L.	.	+	.	.	1	25
Convolvulus arvensis L.	.	.	.	+	1	25
Stellaria media (L.) Vill. subsp. *media*	.	.	.	+	1	25
Galium album Mill. subsp. *album*	.	.	.	+	1	25

Table S6. *Schoenoplectetum lacustris*, *Iridetum pseudacori*, *Typhetum latifoliae*, *Carex hirta community*, *Glycerietum maximae*.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	28	36	31	29	30	33	32	34	35	223	224	221	219	225	227	37	222	38	39	40	127	125	126	43	45	44	41	42	220	226		
Elevation (m a.s.l.)	756	781	780	755	756	756	756	756	781	752	752	756	752	752	752	781	752	756	781	781	781	780	780	756	775	775	756	756	796	752		
Aspect	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	80	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98	100	90	100	100	100	100	100	100	98	100	100	100		
Area (m^2)	50	30	20	10	50	20	20	30	20	10	10	5	20	10	20	8	10	30	6	20	15	5	5	6	50	50	50	30	20	20		
Locality	R	Ar	Ar	PC	PC	PC	PC	PC	Ar	Co	Co	Co	Co	Co	Co	Ar	Co	PC	Ar	Ar	Ar	Ar	Ar	PC	P	P	PC	PC	R	Co		
Char. species of *Schoenoplectetum lacustris* association																																
Schoenoplectus lacustris (L.) Palla	5	5	5	5	4	5	5	5	5	4	4	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	.	.	.	14	47
Char. species of Iridetum pseudacori association																																
Limniris pseudacorus (L.) Fuss	.	.	.	.	.	.	.	.	.	+	+	5	5	5	5	.	2	.	.	.	.	.	.	.	.	.	.	.	1	+	9	30
Char. species of Typhetum latifoliae association																																
Typha latifolia L.	.	.	.	1	.	.	.	.	.	+	+	+	.	+	.	5	4	5	5	4	.	.	.	.	.	.	.	.	.	+	11	37
Species of Carex hirta community																																
Carex hirta L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	5	5	.	3	.	.	.	.	.	5	17
Char. species of Glycerietum maximae association																																
Glyceria maxima (Hartm.) Holmb.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	4	5	5	5	5	4	5	8	27
Char. species of Phragmition communis alliance and higher syntaxa																																
Mentha aquatica L. subsp. *aquatica*	1	3	.	.	.	+	.	.	.	.	.	.	.	.	.	4	.	+	.	.	.	.	.	4	.	.	.	+	.	.	7	23
Phalaris arundinacea subsp. *arundinacea*	.	.	1	2	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	6	20
Rorippa amphibia (L.) Besser	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	6	20
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	1	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	4	13
Alisma plantago-aquatica L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	3	10
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	7
Eleocharis palustris (L.) Roem. et Schult. subsp. *palustris*		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	2	7
Carex acuta L.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Glyceria notata Chevall.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Myosotis scorpioides L. subsp. *scorpioides*	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Scrophularia umbrosa Dumort. subsp. *umbrosa*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Sparganium erectum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	3
Char. species of Potentillion anserinae alliance and higher syntaxa																																
Ranunculus repens L.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	.	1	+	.	.	.	.	.	5	17
Galium album Mill. subsp. *album*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	.	+	.	.	.	.	4	13
Galega officinalis L.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	3	10
Equisetum palustre L.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	3	10
Carex otrubae Podp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	3	10
Rumex conglomeratus Murray	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2	7
Dactylis glomerata L. subsp. *glomerata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	3
Other species																																
Epilobium hirsutum L.	+	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	6	20
Cruciata laevipes Opiz	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	2	7
Convolvulus arvensis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	2	7
Convolvulus sepium L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	2	7
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	3

Sporadic taxa: rel. 1 - *Lolium arundinaceum* (Schreb.) Darbysh. subsp. *arundinaceum*, +; *Poa trivialis* L., +; *Juncus inflexus* L. subsp. *inflexus*, 1; rel. 8 - *Plantago major* L., +; rel. 9 - *Bromus commutatus* Schrad. subsp. *commutatus*, +; *Atriplex patula* L., +; *Bidens tripartita* L. subsp. *tripartita*, +; *Cirsium arvense* (L.) Scop., +; *Thalictrum lucidum* L., +; *Galium aparine* L., +; rel. 12 - *Rubus ulmifolius* Schott, +.

Table S7. *Caricetum vesicariae.*

Relevé number	1	2	3		
Relevé number in the dendrogram (Fig. 2)	111	109	110		
Elevation (m a.s.l.)	781	780	781		
Aspect	-	-	-		
Slope angle (°)	0	0	0		
Total cover (%)	100	100	100		
Area (m²)	40	10	30		
Locality	Ar	Ar	Ar	No. of occurrences	Frequency (%)
Char. species of *Caricetum vesicariae* association and higher syntaxa					
Carex vesicaria L.	4	5	5	3	100
Typha latifolia L.	1	.	.	1	33
Rorippa amphibia (L.) Besser	1	.	.	1	33
Glyceria notata Chevall.	+	.	.	1	33
Other species					
Carex hirta L.	.	+	.	1	33
Galium album Mill. subsp. *album*	.	.	1	1	33
Rumex crispus L.	.	.	+	1	33

Table S8. *Carici otrubae-Juncetum inflexi.*

Relevé number	1	2	3	4	5	6	7	8	9	10	11		
Relevé number in the dendrogram (Fig. 2)	124	115	116	120	119	123	118	114	117	121	122		
Elevation (m a.s.l.)	800	756	781	781	781	781	780	756	780	779	779		
Aspect	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100	100	90	100	100		
Area (m²)	30	10	5	40	20	50	20	10	5	10	5		
Locality	Cc	PC	Ar	Ar	Ar	Ar	Ar	PC	Ar	Ar	Ar	No. of occurrences	Frequency (%)
Char. species of *Carici otrubae-Juncetum inflexi* association													
Juncus inflexus L. subsp. *inflexus*	4	4	5	5	5	5	5	5	5	5	5	11	100
Carex otrubae Podp.	.	.	.	+	.	.	+	.	.	+	.	3	27
Species of *Mentho longifoliae-Juncion inflexi* alliance and higher syntaxa													
Galium album Mill. subsp. *album*	.	.	.	+	+	+	+	.	.	+	+	6	55
Galega officinalis L.	.	.	.	+	+	.	.	.	.	+	+	4	36
Trifolium repens L.	1	2	.	.	.	.	.	+	.	.	.	3	27
Ranunculus repens L.	+	2	.	.	.	.	.	+	.	.	.	3	27
Trifolium resupinatum L.	+	1	.	.	.	.	.	.	.	.	.	2	18
Holcus lanatus L. subsp. *lanatus*	3	.	.	.	.	.	.	.	.	.	.	1	9
Poa pratensis L. subsp. *pratensis*	2	.	.	.	.	.	.	.	.	.	.	1	9
Trifolium fragiferum L. subsp. *fragiferum*	2	.	.	.	.	.	.	.	.	.	.	1	9
Deschampsia cespitosa (L.) P. Beauv. subsp. *cespitosa*	1	.	.	.	.	.	.	.	.	.	.	1	9
Ranunculus neapolitanus Ten.	1	.	.	.	.	.	.	.	.	.	.	1	9
Centaurea jacea L. subsp. *jacea*	.	1	.	.	.	.	.	.	.	.	.	1	9
Trifolium pratense L. subsp. *pratense*	.	1	.	.	.	.	.	.	.	.	.	1	9
Rumex crispus L.	.	.	.	+	.	.	.	.	.	.	.	1	9
Gratiola officinalis L.	.	.	.	.	1	.	.	.	.	.	.	1	9
Carex distans L.	.	.	.	.	.	+	.	.	.	.	.	1	9
Equisetum palustre L.	.	.	.	.	.	+	.	.	.	.	.	1	9
Epilobium parviflorum Schreb.	.	.	.	.	.	+	.	.	.	.	.	1	9
Rumex acetosa L. subsp. *acetosa*	.	.	.	.	.	.	+	.	.	.	.	1	9
Carex hirta L.	.	.	.	.	.	.	.	+	.	.	.	1	9
Alopecurus bulbosus Gouan subsp. *bulbosus*	.	.	.	.	.	.	.	+	.	.	.	1	9
Other species													
Urtica dioica L. subsp. *dioica*	.	.	+	.	+	.	+	.	.	.	.	3	27
Cruciata laevipes Opiz	.	.	.	.	+	+	+	.	.	.	.	3	27
Phalaris arundinacea L. subsp. *arundinacea*	.	1	.	.	.	.	.	+	.	.	.	2	18
Alisma plantago-aquatica L.	.	+	.	.	.	.	.	r	.	.	.	2	18
Carex vesicaria L.	.	.	1	1	.	.	.	.	.	.	.	2	18
Typha latifolia L.	.	.	.	+	.	+	.	.	.	.	.	2	18
Rorippa amphibia (L.) Besser	.	.	.	.	.	+	.	.	.	.	.	1	9
Conium maculatum L. subsp. *maculatum*	.	.	.	.	.	+	.	.	.	.	.	1	9
Myosotis scorpioides L. subsp. *scorpioides*	.	.	.	.	.	.	+	.	.	.	.	1	9
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	.	.	.	.	.	.	+	.	.	.	.	1	9
Eleocharis palustris (L.) Roem. et Schult. subsp. *palustris*	.	.	.	.	.	.	.	r	.	.	.	1	9
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	.	.	.	.	.	.	+	.	1	9

Table S9. *Urtico-Sambucetum ebuli.*

					No. of occurrences	Frequency (%)
Relevé number	1	2	3	4		
Relevé number in the dendrogram (Fig. 2)	213	214	215	216		
Elevation (m a.s.l.)	805	805	760	778		
Aspect	-	-	-	-		
Slope angle (°)	0	0	0	0		
Total cover (%)	100	100	100	100		
Area (m²)	30	30	20	10		
Locality	R	R	PC	An		
Char. species of *Urtico-Sambucetum ebuli* association						
Sambucus ebulus L.	4	4	5	5	4	100
Urtica dioica subsp. *dioica*	+	+	+	1	4	100
Char. species of *Balloto-Conion maculati* alliance and higher syntaxa						
Conium maculatum L. subsp. *maculatum*	.	.	1	1	2	50
Galium aparine L.	.	.	1	3	2	50
Cruciata laevipes Opiz	1	.	.	.	1	25
Silene latifolia Poir.	+	.	.	.	1	25
Ballota nigra L. subsp. *meridionalis* (Bég.) Bég.	.	.	+	.	1	25
Char. species of *Potentillion anserinae* alliance and higher syntaxa						
Galium album Mill. subsp. *album*	2	4	+	.	3	75
Poa trivialis L.	2	2	+	.	3	75
Dactylis glomerata L. subsp. *glomerata*	1	1	1	.	3	75
Achillea millefolium L. subsp. *millefolium*	1	.	.	.	1	25
Centaurea jacea L. subsp. *jacea*	1	.	.	.	1	25
Plantago lanceolata L.	+	.	.	.	1	25
Ranunculus velutinus Ten.	+	.	.	.	1	25
Salvia pratensis L. subsp. *pratensis*	.	1	.	.	1	25
Lolium perenne L.	.	+	.	.	1	25
Other species						
Rubus caesius L.	5	5	.	.	2	50
Sinapis arvensis L. subsp. *arvensis*	r	.	+	.	2	50
Geranium pyrenaicum Burm.f. subsp. *pyrenaicum*	.	+	.	1	2	50
Anisantha rigida (Roth) Hyl.	.	+	.	1	2	50
Arctium lappa L.	.	.	+	1	2	50
Stellaria media (L.) Vill. subsp. *media*	.	.	+	3	2	50
Lamium purpureum L.	.	.	+	+	2	50
Geranium dissectum L.	+	.	.	.	1	25
Cynoglottis barrelieri (All.) Vural & Kit Tan subsp. *barrelieri*	r	.	.	.	1	25
Calepina irregularis (Asso) Thell.	.	.	.	2	1	25

Table S10. *Caricetum ripariae*, *Cyperetum longi*, *Phragmitetum australis*.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	109	106	107	112	113	59	60	25	234	22	235	24	236	55	58	23	20	21	26	56	57		
Elevation (m a.s.l.)	795	757	757	756	756	756	756	795	752	757	752	795	752	756	756	781	781	757	757	756	756		
Aspect	-	-	-	-	-	-	-	-	SSW	-	NNE	-	NNE	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	2	0	25	0	25	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	95	95	100	100	100	100		
Area (m²)	30	20	20	10	30	25	25	50	20	50	20	30	20	50	25	20	6	50	50	25	50		
Locality	R	PC	PC	R	R	PC	PC	R	Co	PC	Co	R	Co	PC	PC	Ar	Ar	PC	PC	PC	PC		
Char. species of *Caricetum ripariae* association																							
Carex riparia Curtis	5	5	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	14
Char. species of *Cyperetum longi* association																							
Cyperus longus L.	.	.	.	4	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	10
Char. species of *Phragmitetum australis* association																							
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	2	1	2	+	2	2	4	4	5	5	4	4	5	5	5	5	5	5	4	3	20	95
Char. species of *Magnocaricion gracilis* alliance																							
Carex acuta L.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	3	14
Carex vesicaria L.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2	10
Char. species of *Phragmition communis* alliance and higher syntaxa																							
Lythrum salicaria L.	.	.	.	.	.	1	1	.	.	.	.	.	+	.	1	.	.	.	+	.	2	6	29
Mentha aquatica L. subsp. *aquatica*	.	.	.	2	+	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	3	14
Phalaris arundinacea L. subsp. *arundinacea*	.	.	.	.	1	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	3	14
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	2	10
Limniris pseudacorus (L.) Fuss	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	5
Scrophularia umbrosa Dumort. subsp. *umbrosa*	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	5
Ingressive species from *Molinio-Arrhenatheretea* class																							
Valeriana officinalis L. subsp. *officinalis*	.	.	1	.	.	2	1	.	.	.	.	.	.	2	1	.	.	.	.	4	5	7	33
Equisetum palustre L.	.	+	+	.	.	1	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	6	29
Lysimachia vulgaris L.	.	2	.	.	.	3	2	3	.	.	.	.	.	.	1	.	.	1	.	.	.	6	29
Galium album Mill. subsp. *album*	.	.	.	.	.	.	.	2	1	1	.	.	.	1	+	.	.	.	.	3	.	6	29
Carex hirta L.	+	.	.	.	.	.	.	2	.	.	.	+	.	+	.	+	.	.	.	.	.	5	24
Thalictrum lucidum L.	+	.	+	+	1	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	5	24
Ranunculus repens L.	.	.	.	.	+	+	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	4	19
Galium debile Desv.	.	.	.	1	+	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	4	19
Hypericum tetrapterum Fr.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	3	14
Carex flacca Schreb. subsp. *erythrostachys* (Hoppe) Holub	+	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	2	10
Gratiola officinalis L.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.	.	2	10
Carex panicea L.	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	10
Epipactis palustris (L.) Crantz	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	10
Galega officinalis L.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	2	.	3	14
Deschampsia cespitosa (L.) P. Beauv. subsp. *cespitosa*	1	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	2	10
Potentilla reptans L.	.	.	.	.	+	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2	10
Epilobium hirsutum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	2	10
Verbena officinalis L.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Cerastium holosteoides Fr.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Lysimachia nummularia L.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Lathyrus pratensis L. subsp. *pratensis*	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Juncus inflexus L. subsp. *inflexus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	5
Carex otrubae Podp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	5
Dactylorhiza incarnata (L.) Soó subsp. *incarnata*	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Agrostis stolonifera L. subsp. *stolonifera*	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Rumex conglomeratus Murray	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Lychnis flos-cuculi L. subsp. *flos-cuculi*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Poa pratensis L. subsp. *pratensis*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
Dactylis glomerata L. subsp. *glomerata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	5
Other species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Rubus ulmifolius Schott	.	.	.	.	.	.	.	1	2	.	+	.	2	.	.	.	.	.	.	.	.	4	19
Cirsium arvense (L.) Scop.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	1	+	4	19
Galium aparine L.	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	3	14
Lactuca sativa L. subsp. *serriola* (L.) Galasso, Banfi, Bartolucci & Ardenghi	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	3	14
Cirsium creticum (Lam.) d'Urv. subsp. *triumfetti* (Lacaita) Werner	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	3	.	3	14
Urtica dioica L. subsp. *dioica*	.	.	.	.	.	.	.	.	4	3	4	.	.	.	.	.	.	.	.	.	.	3	14
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	10
Pulicaria dysenterica (L.) Bernh.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	+	2	10

Sporadic taxa: rel. 1 - *Fallopia convolvulus* (L.) Á.Löve, +; rel. 7 - *Anisantha sterilis* (L.) Nevski, 1; rel. 8 - *Arctium lappa* L., +; rel. 10 - *Conium maculatum* L. subsp. *maculatum*, 1; *Dipsacus fullonum* L. subsp. *fullonum*, +; rel. 12 - *Briza media* L., +; rel. 19 - *Equisetum ramosissimum* Desf., +; *Pastinaca sativa* L. subsp. (Req. ex Godr.) Čelak., +.

Table S11. *Polygono lapathifolii-Xanthietum italici*, *Bidentetum tripartitae*.

Relevé number	1	2	3	4	5	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	212	209	210	208	211		
Elevation (m a.s.l.)	800	796	796	756	796		
Aspect	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0		
Total cover (%)	70	80	80	100	85		
Area (m²)	20	6	6	5	25		
Locality	R	R	R	PC	R		
Char. species of *Polygono lapathifolii-Xanthietum italici* association and higher syntaxa							
Xanthium italicum Moretti	5	.	.	.	.	1	20
Char. species of *Polygono lapathifolii-Bidentetum tripartitae* association and higher syntaxa							
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	2	1	4	3	4	5	100
Bidens tripartita L. subsp. *tripartita*	.	3	1	3	3	4	80
Char. species of *Bidentetea tripartitae* class							
Xanthium strumarium L. subsp. *strumarium*	.	.	.	.	+	1	20
Char. species of *Potentillion anserinae* alliance and higher syntaxa							
Plantago major L.	+	.	+	2	2	4	80
Verbena officinalis L.	.	+	+	+	1	4	80
Lolium multiflorum Lam.	.	.	+	+	+	3	60
Lotus tenuis Waldst. & Kit. ex Willd.	.	2	+	.	.	2	40
Ranunculus repens L.	.	1	.	1	.	2	40
Potentilla reptans L.	+	.	.	.	.	1	20
Galium album Mill. subsp. *album*	+	.	.	.	.	1	20
Gratiola officinalis L.	.	2	.	.	.	1	20
Galega officinalis L.	.	.	.	2	.	1	20
Poa trivialis L.	.	.	.	+	.	1	20
Centaurea jacea L. subsp. *jacea*	.	.	.	.	+	1	20
Other species							
Anthemis cotula L.	+	+	+	+	2	5	100
Sonchus asper (L.) Hill subsp. *asper*	1	+	.	+	+	4	80
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	1	+	+	+	4	80
Helminthotheca echioides (L.) Holub	+	1	.	.	.	2	40
Sinapis arvensis L. subsp. *arvensis*	+	+	.	.	.	2	40
Epilobium tetragonum L. subsp. lamyi (F.W.Schultz) Nyman	.	+	+	.	.	2	40
Elymus repens (L.) Gould subsp. *repens*	1	.	.	+	.	2	40
Amaranthus retroflexus L.	1	.	.	+	.	2	40
Mercurialis annua L.	2	.	.	.	.	1	20
Rubus caesius L.	2	.	.	.	.	1	20
Veronica hederifolia L.	1	.	.	.	.	1	20
Mentha longifolia (L.) L.	1	.	.	.	.	1	20
Convolvulus arvensis L.	1	.	.	.	.	1	20
Cirsium arvense (L.) Scop.	+	.	.	.	.	1	20
Achillea collina (Becker ex Wirtg.) Heimerl	+	.	.	.	.	1	20
Cichorium intybus L.	+	.	.	.	.	1	20
Heliotropium europaeum L.	+	.	.	.	.	1	20
Capsella bursa-pastoris (L.) Medik. subsp. *bursa-pastoris*	+	.	.	.	.	1	20
Chenopodium album L. subsp. *album*	+	.	.	.	.	1	20
Lysimachia arvensis (L.) U.Manns & Anderb. subsp. *arvensis*	+	.	.	.	.	1	20
Lactuca saligna L.	.	+	.	.	.	1	20
Galeopsis angustifolia Ehrh. ex Hoffm. subsp. *angustifolia*	.	.	+	.	.	1	20
Anthemis arvensis L. subsp. *arvensis*	.	.	.	1	.	1	20
Atriplex patula L.	.	.	.	+	.	1	20
Viola arvensis Murray subsp. *arvensis*	.	.	.	.	+	1	20
Legousia speculum-veneris (L.) Chaix	.	.	.	.	+	1	20
Geranium pyrenaicum Burm.f. subsp. *pyrenaicum*	.	.	.	.	+	1	20
Artemisia vulgaris L.	.	.	.	.	+	1	20
Centaurea cyanus L.	.	.	.	.	+	1	20
Papaver rhoeas L. subsp. *rhoeas*	.	.	.	.	+	1	20
Carduus acicularis Bertol.	.	.	.	.	+	1	20

Table S12. *Epilobium hirsutum* community, *Galega officinalis* community.

Relevé number	1	2	3	4	5	6	7	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	217	201	202	203	204	200	205		
Elevation (m a.s.l.)	796	780	781	756	796	756	756		
Aspect	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100		
Area (m²)	20	10	5	6	5	10	5		
Locality	R	Ar	Ar	PC	R	PC	PC		
Species of the *Epilobium hirsutum* community									
Epilobium hirsutum L.	5	.	.	.	+	.	.	2	29
Species of *Galega officinalis* community									
Galega officinalis L.	1	5	4	4	4	5	5	7	100
Char. species of *Potentillion anserinae* alliance and higher syntaxa									
Ranunculus repens L.	2	.	.	5	3	+	+	5	71
Poa trivialis L.	.	2	1	.	.	+	.	3	43
Galium album Mill. subsp. *album*	.	4	4	.	.	.	.	2	29
Rumex crispus L.	+	.	.	+	.	.	.	2	29
Deschampsia cespitosa (L.) P. Beauv. subsp. *cespitosa*	1	.	.	.	+	.	.	2	29
Plantago major L.	.	.	.	+	.	.	1	2	29
Lotus corniculatus L. subsp. *corniculatus*	+	.	.	.	.	.	.	1	14
Carex otrubae Podp.	.	1	.	.	.	.	.	1	14
Bromus racemosus L. subsp. *racemosus*	.	+	.	.	.	.	.	1	14
Rumex acetosa L. subsp. *acetosa*	.	+	.	.	.	.	.	1	14
Gratiola officinalis L.	.	+	.	.	.	.	.	1	14
Dactylis glomerata L. subsp. *glomerata*	.	.	1	.	.	.	.	1	14
Carex hirta L.	.	.	1	.	.	.	.	1	14
Leucanthemum vulgare (Vaill.) Lam. subsp. *vulgare*	.	.	+	.	.	.	.	1	14
Daucus carota L. subsp. *carota*	.	.	.	+	.	.	.	1	14
Thalictrum lucidum L.	.	.	.	.	+	.	.	1	14
Verbena officinalis L.	.	.	.	.	+	.	.	1	14
Juncus inflexus L. subsp. *inflexus*	.	.	.	.	.	1	.	1	14
Lolium perenne L.	.	.	.	.	.	+	.	1	14
Trifolium repens L.	.	.	.	.	.	.	+	1	14
Other species									
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	+	.	+	.	+	.	.	3	43
Phalaris arundinacea L. subsp. *arundinacea*	+	+	.	.	.	r	.	3	43
Lactuca sativa L. subsp. *serriola* (L.) Galasso, Banfi, Bartolucci & Ardenghi	+	.	.	+	+	.	.	3	43
Cirsium arvense (L.) Scop.	.	1	.	1	.	2	.	3	43
Cruciata laevipes Opiz	.	1	2	.	.	.	.	2	29
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	.	+	.	2	2	29
Elymus repens (L.) Gould subsp. *repens*	1	.	.	.	.	.	.	1	14
Geranium dissectum L.	.	+	.	.	.	.	.	1	14
Convolvulus arvensis L.	.	.	+	.	.	.	.	1	14
Conium maculatum L. subsp. *maculatum*	.	.	1	.	.	.	.	1	14
Medicago lupulina L.	.	.	.	1	.	.	.	1	14
Pastinaca sativa L. subsp. *urens* (Req. ex Godr.) Čelak.	.	.	.	1	.	.	.	1	14
Malva sylvestris L.	.	.	.	+	.	.	.	1	14
Mentha aquatica L. subsp. *aquatica*	.	.	.	+	.	.	.	1	14
Capsella bursa-pastoris (L.) Medik. subsp. *bursa-pastoris*	.	.	.	+	.	.	.	1	14
Chenopodium album L. subsp. *album*	.	.	.	+	.	.	.	1	14
Anthemis cotula L.	.	.	.	.	+	.	.	1	14
Verbascum blattaria L.	.	.	.	.	+	.	.	1	14
Juncus articulatus L. subsp. *articulatus*	.	.	.	.	.	r	.	1	14
Bidens tripartita L. subsp. *tripartita*	.	.	.	.	.	.	1	1	14
Atriplex patula L.	.	.	.	.	.	.	+	1	14
Anthemis arvensis L. subsp. *arvensis*	.	.	.	.	.	.	+	1	14

Table S13. *Deschampsio-Caricetum distantis*.

Relevé number	1	2	3	4	5	6	7	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	181	178	179	175	180	176	177		
Elevation (m a.s.l.)	800	777	777	792	777	795	795		
Aspect	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0		
Total cover (%)	100	100	100	100	100	100	100		
Area (m^2)	30	150	150	200	150	150	150		
Locality	Cc	An	An	R	An	R	R		
Char. species of *Deschampsio-Caricetum distantis* association									
Deschampsia cespitosa (L.) P. Beauv. subsp. *cespitosa*	4	5	4	3	4	5	5	7	100
Carex distans L.	+	+	+	+	+	+	2	7	100
Char. species of *Ranunculion velutini* alliance and *Trifolio-Hordeetalia* order									
Lolium arundinaceum (Schreb.) Darbysh. subsp. *arundinaceum*	1	.	+	+	+	2	2	6	86
Bellevalia romana (L.) Sweet	.	+	+	+	1	.	.	4	57
Ranunculus velutinus Ten.	.	+	.	+	.	.	+	3	43
Anacamptis laxiflora (Lam.) R.M.Bateman, Pridgeon & M.W.Chase	.	.	.	+	.	+	+	3	43
Bromus racemosus L. subsp. *racemosus*	+	.	.	.	.	+	.	2	29
Trifolium resupinatum L.	.	.	2	.	1	.	.	2	29
Alopecurus rendlei Eig	.	.	.	.	+	.	.	1	14
Species of *Molinio-Arrhenatheretea* class									
Ranunculus repens L.	1	2	1	2	2	1	+	7	100
Centaurea jacea L. subsp. *jacea*	.	2	2	3	3	1	2	6	86
Thalictrum lucidum L.	.	2	1	1	1	+	.	5	71
Galium debile Desv.	.	1	3	.	1	+	1	5	71
Trifolium pratense L. subsp. *pratense*	.	1	1	.	3	+	1	5	71
Gratiola officinalis L.	.	2	3	1	1	.	.	4	57
Lotus corniculatus L. subsp. *corniculatus*	.	1	.	.	2	1	1	4	57
Carex flacca Schreb. subsp. *erythrostachys* (Hoppe) Holub	.	.	.	2	2	1	1	4	57
Anthoxanthum odoratum L.	.	.	.	1	+	1	1	4	57
Carex hirta L.	2	1	.	.	.	+	.	3	43
Plantago lanceolata L.	.	.	.	1	.	1	+	3	43
Prunella vulgaris L. subsp. *vulgaris*	.	2	2	.	1	.	.	3	43
Poa pratensis L. subsp. *pratensis*	2	.	.	1	.	.	.	2	29
Potentilla reptans L.	.	1	+	.	.	.	.	2	29
Holcus lanatus L. subsp. *lanatus*	.	1	.	.	.	.	+	2	29
Plantago lanceolata L.	.	1	.	.	1	.	.	2	29
Lotus tenuis Waldst. & Kit. ex Willd.	.	+	.	.	1	.	.	2	29
Alopecurus bulbosus Gouan subsp. *bulbosus*	.	.	1	.	.	+	.	2	29
Oenanthe fistulosa L.	.	.	.	+	+	.	.	2	29
Trifolium striatum L. subsp. *striatum*	.	.	.	+	+	.	.	2	29
Carex panicea L.	.	.	.	2	.	+	.	2	29
Dactylis glomerata L. subsp. *glomerata*	2	.	.	.	.	.	.	1	14
Rumex conglomeratus Murray	1	.	.	.	.	.	.	1	14
Galium album Mill. subsp. *album*	1	.	.	.	.	.	.	1	14
Galium verum L.	+	.	.	.	.	.	.	1	14
Equisetum palustre L.	+	.	.	.	.	.	.	1	14
Rumex acetosa L. subsp. *acetosa*	+	.	.	.	.	.	.	1	14
Rumex obtusifolius L. subsp. *obtusifolius*	+	.	.	.	.	.	.	1	14
Lysimachia nummularia L.	.	1	.	.	.	.	.	1	14
Cynosurus cristatus L.	.	+	.	.	.	.	.	1	14
Leontodon hispidus L.	.	.	+	.	.	.	.	1	14
Dactylorhiza incarnata (L.) Soó subsp. *incarnata*	.	.	.	+	.	.	.	1	14
Lychnis flos-cuculi L. subsp. *flos-cuculi*	.	.	.	.	.	1	.	1	14
Other species									
Taraxacum palustre (group)	.	.	1	2	+	+	+	5	71
Phalaris arundinacea L. subsp. *arundinacea*	.	1	1	1	1	.	.	4	57
Briza media L.	.	2	1	.	.	.	+	3	43
Mentha aquatica L. subsp. *aquatica*	.	.	+	+	+	.	.	3	43
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	.	.	+	+	2	29
Cirsium arvense (L.) Scop.	1	.	.	.	.	.	.	1	14
Fallopia convolvulus (L.) Á.Löve	+	.	.	.	.	.	.	1	14
Conium maculatum L. subsp. *maculatum*	+	.	.	.	.	.	.	1	14
Sambucus ebulus L.	+	.	.	.	.	.	.	1	14
Lactuca sativa L. subsp. *serriola* (L.) Galasso, Banfi, Bartolucci & Ardenghi	+	.	.	.	.	.	.	1	14
Pentanema salicinum (L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort.	.	2	.	.	.	.	.	1	14
Tragopogon porrifolius L.	.	.	+	.	.	.	.	1	14
Anacamptis morio (L.) R.M.Bateman, Pridgeon & M.W.Chase	.	.	.	+	.	.	.	1	14
Ajuga reptans L.	.	.	.	.	.	.	+	1	14

Table S14. *Hordeo-Ranunculetum velutini.*

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	183	185	187	184	186	196	197	198	193	194	195	237	238	172	173	188	189	191	192	161	163	168	169	166	167	236	170	171	181	164	190	158	182	160	159	162	165		
Elevation (m a.s.l.)	800	797	797	797	797	800	756	756	795	795	780	752	752	800	800	778	778	800	800	779	780	758	806	757	757	752	790	780	800	782	778	780	778	782	779	781	782		
Aspect	-	-	-	-	-	-	-	-	-	-	NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	W	-	W	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	2	0		
Total cover (%)	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100	100		
Area (m^2)	100	100	100	100	100	100	100	100	80	80	75	100	100	150	100	150	150	200	200	150	100	150	150	200	200	100	200	200	100	250	100	100	150	250	100	50	100		
Locality	R	R	R	R	R	Cc	PC	PC	R	R	An	Co	Co	Cc	Cc	An	An	Cc	Cc	Ar	Ar	PC	R	PC	PC	Co	P	P	R	Ar	An	Ar	An	Ar	Ar	Ar	Ar		
Char. species of *Hordeo-Ranunculetum velutini* association																																							
Alopecurus rendlei Eig	.	.	.	.	.	+	.	.	.	.	.	3	2	1	1	1	2	1	3	3	1	2	3	1	2	2	4	3	3	3	3	1	.	+	2	1	3	26	70
Hordeum secalinum Schreb.	.	4	1	1	1	.	+	.	.	.	1	.	.	1	1	4	4	1	2	1	+	.	.	.	.	.	.	.	.	3	5	2	4	3	2	2	3	22	59
Bromus racemosus L. subsp. *racemosus*	.	.	+	+	+	1	.	.	.	.	.	4	.	3	2	.	.	.	+	1	.	+	.	1	.	.	1	3	2	.	.	.	+	.	2	+	.	17	46
Trifolium dubium Sibth.	.	.	.	.	.	1	.	+	2	+	.	.	.	.	+	.	+	.	.	.	.	.	.	+	.	+	+	.	.	+	.	+	.	+	.	.	+	13	35
Bellevalia romana (L.) Sweet	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5
Trifolium resupinatum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2	5
Char. species of *Ranunculion velutini* alliance and *Trifolio-Hordeetalia* order																																							
Ranunculus velutinus Ten.	2	1	+	1	+	3	+	1	.	.	1	1	2	4	3	3	+	1	1	1	5	5	5	4	4	3	5	4	+	2	2	5	3	1	3	2	2	35	95
Lolium arundinaceum (Schreb.) Darbysh. subsp. *arundinaceum*	2	2	4	4	4	2	1	+	2	2	2	.	.	.	.	.	.	.	.	+	1	.	.	+	1	.	.	.	1	+	.	.	2	1	.	.	+	20	54
Gaudinia fragilis (L.) P.Beauv.	.	+	1	2	1	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	1	.	.	.	.	9	24
Anacamptis laxiflora (Lam.) R.M.Bateman, Pridgeon & M.W.Chase	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	5	14
Species of *Molinio-Arrhenatheretea* class																																							
Cynosurus cristatus L.	4	2	2	3	2	+	+	+	+	1	1	.	1	+	1	3	1	1	+	1	+	2	.	1	1	3	2	1	5	4	+	3	5	4	3	4	4	35	95
Trifolium pratense L. subsp. *pratense*	2	+	+	+	.	1	+	1	1	2	1	.	2	1	+	1	3	+	+	.	+	2	1	3	2	2	1	2	1	4	2	1	2	1	2	2	3	34	92
Centaurea jacea L. subsp. *jacea*	3	2	2	3	2	1	1	2	3	3	2	.	+	+	1	3	2	+	+	3	4	4	5	5	4	2	1	1	1	2	3	1	+	2	2	.	.	34	92
Dactylis glomerata L. subsp. *glomerata*	1	2	3	3	2	2	1	1	1	2	4	1	2	2	3	2	3	3	3	.	.	1	.	2	2	1	1	.	+	+	.	+	3	1	2	1	1	32	86
Anthoxanthum odoratum L.	2	1	1	2	1	.	+	+	.	1	.	3	2	+	+	.	1	.	.	.	1	2	4	3	3	3	2	2	1	1	+	+	1	1	1	1	2	30	81
Holcus lanatus L. subsp. *lanatus*	1	.	1	2	2	.	.	.	1	1	2	.	.	2	+	2	1	1	+	.	2	.	.	1	1	.	2	1	.	1	.	1	2	4	.	1	3	24	65
Rhinanthus minor L.	2	+	+	1	2	.	2	+	2	+	.	.	.	+	+	+	1	+	.	.	.	r	.	+	.	+	.	+	+	+	+	.	1	.	+	.	.	23	62
Poa pratensis L. subsp. *pratensis*	.	.	.	.	.	2	+	1	.	.	.	3	3	3	2	.	.	+	1	2	1	.	.	+	1	.	2	2	.	2	3	1	.	2	3	.	3	21	57
Rumex acetosa L. subsp. *acetosa*	+	+	+	1	+	+	.	.	.	.	.	.	.	+	+	.	+	.	+	.	+	.	.	.	.	+	+	+	.	+	+	+	.	+	+	.	+	20	54
Lolium perenne L.	.	.	.	.	.	1	+	.	+	+	.	+	.	2	1	.	.	+	.	2	.	.	.	.	+	2	+	1	3	.	.	+	1	2	3	4	3	20	54
Leontodon hispidus L. subsp. *hispidus*	.	1	1	1	1	+	1	+	+	.	1	.	1	.	.	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	17	46
Poa trivialis L.	2	1	1	2	2	.	.	.	.	.	2	.	.	.	.	2	.	2	2	.	.	.	.	.	.	+	1	.	2	.	1	.	1	.	1	1	.	16	43
Lychnis flos-cuculi L. subsp. *flos-cuculi*	+	+	.	+	+	.	.	.	+	+	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	1	.	+	3	+	.	+	+	1	.	1	16	43
Lotus corniculatus L. subsp. *corniculatus*	2	.	.	.	.	.	1	+	.	.	.	.	2	.	.	.	.	.	.	+	+	+	1	2	1	.	.	.	+	+	.	.	1	+	+	.	+	16	43
Trifolium repens L.	+	.	+	.	.	1	.	.	.	.	.	.	.	1	+	.	.	.	.	+	.	1	1	1	1	.	.	+	.	.	.	+	.	1	1	1	.	15	41
Cerastium holosteoides Fr.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	1	2	+	.	.	+	2	2	+	.	+	2	.	.	+	.	.	+	.	+	1	15	41
Plantago lanceolata L.	.	.	.	.	.	+	+	+	.	.	.	.	1	.	.	.	.	+	+	+	.	+	+	+	+	1	+	+	.	.	.	.	+	.	.	.	.	15	41
Leucanthemum vulgare (Vaill.) Lam. subsp. *vulgare*	+	r	.	1	+	+	.	.	1	.	.	.	1	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	+	+	13	35
Arrhenatherum elatius (L.) P.Beauv. ex J.Presl & C.Presl subsp. *elatius*	.	.	.	.	.	1	+	+	1	.	2	.	2	2	2	4	4	5	4	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	13	35
Bellis perennis L.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	r	.	.	.	.	+	1	1	+	+	+	+	+	.	.	.	.	.	.	.	+	+	12	32
Briza media L.	3	3	2	1	3	+	+	1	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	12	32
Carex hirta L.	.	.	.	.	.	.	+	.	.	.	.	+	.	1	.	.	.	.	2	.	+	.	+	+	.	+	+	+	.	.	.	.	.	r	.	.	.	11	30
Colchicum lusitanum Brot.	+	+	.	+	+	.	.	+	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	.	11	30
Ranunculus neapolitanus Ten.	+	.	.	.	.	2	.	.	2	2	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	1	.	.	+	.	10	27
Galium verum subsp. *verum*	.	1	.	.	.	+	2	1	1	.	+	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	10	27
Daucus carota L. subsp. *carota*	+	r	.	+	r	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	+	.	.	9	24
Carex flacca Schreb. subsp. *erythrostachys* (Hoppe) Holub	1	.	.	.	+	.	.	.	+	+	1	1	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	8	22
Ranunculus repens L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	6	16

Table S14. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	183	185	187	184	186	196	197	198	193	194	195	237	238	172	173	188	189	191	192	161	163	168	169	166	167	236	170	171	181	164	190	158	182	160	159	162	165		
Elevation (m a.s.l.)	800	797	797	797	797	800	756	756	795	795	780	752	752	800	800	778	778	800	800	779	780	758	806	757	757	752	790	780	800	782	778	780	778	782	779	781	782		
Aspect	-	-	-	-	-	-	-	-	-	-	NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	W	-	W	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	2	0		
Total cover (%)	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100	100		
Area (m²)	100	100	100	100	100	100	100	100	80	80	75	100	100	150	100	150	150	200	200	150	100	150	150	200	200	100	200	200	100	250	100	100	150	250	100	50	100		
Locality	R	R	R	R	R	Cc	PC	PC	R	R	An	Co	Co	Cc	Cc	An	An	Cc	Cc	Ar	Ar	PC	R	PC	PC	Co	P	P	R	Ar	An	Ar	An	Ar	Ar	Ar	Ar		
Trifolium striatum L. subsp. *striatum*	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	6	16
Salvia pratensis L. subsp. *pratensis*	.	.	.	.	.	1	2	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	6	16
Potentilla reptans L.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	5	14
Thalictrum lucidum L.	.	.	+	.	.	.	.	.	.	.	r	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	5	14
Alopecurus bulbosus Gouan subsp. *bulbosus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	+	.	3	1	+	.	5	14
Tragopogon porrifolius L.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	5	14
Galium album Mill. subsp. *album*	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	5	14
Deschampsia cespitosa (L.) P. Beauv. subsp. *cespitosa*	1	.	2	.	.	.	.	.	+	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	14
Achillea millefolium L. subsp. *millefolium*	.	.	.	.	.	+	1	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	11
Tragopogon pratensis L.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	4	11
Carex distans L.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	.	.	.	.	.	.	.	.	.	.	.	4	11
Lolium arundinaceum (Schreb.) Darbysh. subsp. *arundinaceum*	.	.	.	.	.	.	.	.	.	.	.	4	3	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	3	8
Galium debile Desv.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	3	8
Rumex crispus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2	5
Mentha longifolia (L.) L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5
Carex otrubae Podp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	2	5
Equisetum palustre L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5
Bromus commutatus Schrad. subsp. *commutatus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Dactylorhiza incarnata (L.) Soó subsp. *incarnata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Oenanthe fistulosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Ranunculus sardous Crantz	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	3
Lathyrus pratensis L. subsp. *pratensis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	3
Lolium multiflorum Lam.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	3
Gymnadenia conopsea (L.) R.Br.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Gratiola officinalis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Other species																																							
Cerastium ligusticum Viv.	+	+	+	+	+	+	.	.	+	.	.	+	.	3	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	+	+	2	.	.	15	41
Taraxacum F.H.Wigg. sect. *Taraxacum*	.	.	.	.	.	+	+	+	.	.	.	.	2	.	.	.	.	+	.	.	.	2	1	+	+	+	+	1	.	.	.	.	.	+	+	.	.	14	38
Crepis vesicaria L. subsp. *vesicaria*	.	.	.	.	.	+	+	.	.	.	.	+	2	+	+	.	.	+	+	.	.	.	.	.	.	+	+	+	.	.	.	.	1	.	.	.	.	12	32
Cruciata laevipes Opiz	.	.	.	.	.	.	+	.	.	.	.	+	+	+	.	1	+	+	+	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	11	30
Geranium dissectum L.	.	.	.	.	.	+	+	.	.	.	.	1	.	+	+	.	.	.	2	.	.	+	.	.	.	+	.	+	.	.	.	.	.	.	.	+	.	10	27
Bromus hordeaceus L. subsp. *hordeaceus*	.	.	.	.	.	2	2	.	.	.	.	.	+	.	.	.	.	1	2	.	.	.	.	.	.	2	1	1	.	1	.	.	.	1	.	.	.	10	27
Bromopsis erecta (Huds.) Fourr. subsp. *erecta*	.	.	.	.	.	4	4	4	3	3	5	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	9	24
Sherardia arvensis L.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	+	.	.	.	1	.	+	.	.	.	.	.	.	.	+	.	8	22
Phalaris arundinacea L. subsp. *arundinacea*	.	.	.	.	r	.	.	.	.	.	.	3	.	.	.	.	.	.	.	2	.	3	.	.	.	2	.	.	.	.	.	.	.	r	1	.	.	7	19
Trifolium incarnatum L. subsp. *molinerii* (Balb. ex Hornem.) Ces.	.	.	.	1	.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	+	.	7	19
Poterium sanguisorba L. subsp. *balearicum* (Bourg. ex Nyman) Stace	.	.	.	.	.	+	1	+	3	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	6	16
Vicia angustifolia L.	.	.	.	.	.	+	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	5	14
Onobrychis viciifolia Scop.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	5	14
Festuca rubra L. s.l.	.	.	.	.	.	.	.	2	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	5	14
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	4	11
Anisantha sterilis (L.) Nevski	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	11

Table S14. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	183	185	187	184	186	196	197	198	193	194	195	237	238	172	173	188	189	191	192	161	163	168	169	166	167	236	170	171	181	164	190	158	182	160	159	162	165		
Elevation (m a.s.l.)	800	797	797	797	797	800	756	756	795	795	780	752	752	800	800	778	778	800	800	779	780	758	806	757	757	752	790	780	800	782	778	780	778	782	779	781	782		
Aspect	-	-	-	-	-	-	-	-	-	-	NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W	-	-	-	W	-	W	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	2	0		
Total cover (%)	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100	100		
Area (m²)	100	100	100	100	100	100	100	100	80	80	75	100	100	150	100	150	150	200	200	150	100	150	150	200	200	100	200	200	100	250	100	100	150	250	100	50	100		
Locality	R	R	R	R	R	Cc	PC	PC	R	R	An	Co	Co	Cc	Cc	An	An	Cc	Cc	Ar	Ar	PC	R	PC	PC	Co	P	P	R	Ar	An	Ar	An	Ar	Ar	Ar	Ar		
Campanula rapunculus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	4	11
Ornithogalum divergens Boreau	.	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	4	11
Convolvulus arvensis L.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	4	11
Dasypyrum villosum (L.) P.Candargy	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	11
Knautia calycina (C.Presl) Guss.	.	.	.	+	.	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	11
Ajuga reptans L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	3	8
Knautia integrifolia (L.) Bertol. subsp. *integrifolia*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	3	8
Anacamptis morio (L.) R.M.Bateman, Pridgeon & M.W.Chase	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5
Equisetum ramosissimum Desf.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5
Trifolium campestre Schreb.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5
Fallopia convolvulus (L.) Á.Löve	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	2	5

Sporadic taxa: rel. 1 - *Festuca* sp., 1; rel. 5 - *Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis*, +; rel. 7: *Capsella bursa-pastoris* (L.) Medik. subsp. *bursa-pastoris*, +; rel. 11 - *Pentanema salicinum* (L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort., 2; rel. 12 - *Galium aparine* L., +; rel. 13 - *Cichorium intybus* L., 1; rel. 6 - *Anthemis arvensis* L. subsp. *arvensis*, +; *Medicago arabica* (L.) Huds., 2; *Geranium molle* L., 1; rel. 14 - *Crepis sancta* subsp. *nemausensis*, +; rel. 15 - *Calepina irregularis* (Asso) Thell., +; *Stellaria media* (L.) Vill. subsp. *media*, +; *Veronica arvensis* L., +; rel. 19 - *Cirsium arvense* (L.) Scop., 1; rel. 24 - *Mentha aquatica* L. subsp. *aquatica*, +; rel. 26 - *Veronica arvensis* L., +; *Cynosurus echinatus* L., +; rel. 27 - *Elymus repens* (L.) Gould subsp. *repens*, +; *Saxifraga bulbifera* L., +; rel. 28 - *Calepina irregularis* (Asso) Thell., +; *Myosotis arvensis* (L.) Hill subsp. *arvensis*, +; *Vicia sativa* L., +; *Medicago sativa* L., +; rel. 33 - *Stellaria media* (L.) Vill. subsp. *media*, +; *Medicago lupulina* L., +.

Table S15. *Sparganietum erecti*.

Relevé number	1	2	3	4	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	48	49	46	47		
Elevation (m a.s.l.)	756	756	756	756		
Aspect	-	-	-	-		
Slope angle (°)	0	0	0	0		
Total cover (%)	100	100	100	100		
Area (m^2)	8	10	10	8		
Locality	PC	PC	PC	PC		
Char. species of *Sparganietum erecti* association and higher syntaxa						
Sparganium erectum L.	4	4	4	3	4	100
Veronica beccabunga L. subsp. *beccabunga*	+	.	+	1	3	75
Lythrum salicaria L.	+	.	.	+	2	50
Phalaris arundinacea L. subsp. *arundinacea*	1	1	.	.	2	50
Mentha aquatica L. subsp. *aquatica*	+	+	.	.	2	50
Galium palustre L. subsp. *elongatum* (C.Presl) Lange	.	+	.	.	1	25
Carex acuta L.	.	.	1	.	1	25
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	+	1	25
Alisma plantago-aquatica L.	.	.	.	+	1	25
Other species						
Ranunculus repens L.	+	1	+	.	3	75
Agrostis stolonifera L. subsp. *stolonifera*	+	+	.	.	2	50
Galega officinalis L.	+	.	.	.	1	25
Lotus tenuis Waldst. & Kit. ex Willd.	+	.	.	.	1	25
Cirsium arvense (L.) Scop.	+	.	.	.	1	25
Carex otrubae Podp.	.	+	.	.	1	25
Oenanthe fistulosa L.	.	+	.	.	1	25
Potentilla reptans L.	.	+	.	.	1	25
Juncus inflexus L. subsp. *inflexus*	.	+	.	.	1	25
Lysimachia vulgaris L.	.	.	.	+	1	25
Lycopus europaeus L.	.	.	.	+	1	25

Table S16. *Caricetum gracilis.*

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	27	89	87	91	93	95	96	97	98	94	100	92	99	88	90		
Elevation (m a.s.l.)	777	777	795	756	794	776	777	780	780	778	781	756	777	791	791		
Aspect	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	95	100	100	100	90	80	90	100	100	100	100	100	100	100	100		
Area (m²)	10	20	25	10	20	20	8	40	40	40	40	10	50	70	70		
Locality	An	An	R	PC	R	An	An	Ar	Ar	An	Ar	PC	An	R	R		
Char. species of *Caricetum gracilis* association																	
Carex acuta L.	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	15	100
Char. species of *Magnocaricion gracilis* alliance and Magnocaricetalia order																	
Phalaris arundinacea L. subsp. *arundinacea*	.	1	+	1	+	.	+	.	.	.	.	+	.	1	.	7	47
Galium palustre L. subsp. *elongatum* (C.Presl) Lange	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	3	20
Mentha aquatica L. subsp. *aquatica*	.	+	1	.	.	.	.	.	.	.	.	.	.	1	2	4	27
Carex vesicaria L.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	2	13
Species of *Phragmito-Magnocaricetea* class																	
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	4	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	13
Ranunculus ophioglossifolius Vill.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	13
Equisetum fluviatile L.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	7
Myosotis scorpioides L. subsp. *scorpioides*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	7
Other species																	
Ranunculus repens L.	2	2	1	1	1	1	.	.	.	.	.	.	.	.	1	7	47
Potentilla reptans L.	2	.	.	.	.	1	1	.	.	+	.	.	.	.	.	4	27
Gratiola officinalis L.	.	+	1	.	.	.	.	.	.	.	.	.	.	+	.	3	20
Thalictrum lucidum L.	.	.	.	.	1	+	.	.	.	+	.	.	.	.	.	3	20
Galium album Mill. subsp. *album*	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	3	20
Convolvulus arvensis L.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	3	20
Epilobium hirsutum L.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	13
Centaurea jacea L. subsp. *jacea*	+	.	.	.	.	r	.	.	.	.	.	.	.	.	.	2	13
Oenanthe fistulosa L.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	1	2	13
Carex otrubae Podp.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	2	13
Cruciata laevipes Opiz	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	2	13
Ranunculus sardous Crantz	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Rorippa sylvestris (L.) Besser subsp. *sylvestris*	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Trifolium resupinatum L.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Alopecurus bulbosus Gouan subsp. *bulbosus*	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Lycopus europaeus L.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	7
Galium debile Desv.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	7
Cirsium arvense (L.) Scop.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	7
Holcus lanatus L. subsp. *lanatus*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	7
Equisetum palustre L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	7
Dactilis glomerata L. subsp. *glomerata*	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	7
Oenanthe silaifolia M.Bieb.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	7

Table S17. *Potentilla reptans* community.

Relevé number	1	2	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	206	207		
Elevation (m a.s.l.)	793	778		
Aspect	-	-		
Slope angle (°)	0	0		
Total cover (%)	100	90		
Area (m^2)	50	40		
Locality	R	An		
Species of *Potentilla reptans* community				
Potentilla reptans L.	5	4	2	100
Rumex crispus L.	1	2	2	100
Mentha pulegium L. subsp. *pulegium*	1	+	2	100
Species of *Molinio-Arrhenatheretea* class				
Oenanthe fistulosa L.	+	+	2	100
Thalictrum lucidum L.	.	+	1	50
Other species				
Phalaris arundinacea L. subsp. *arundinacea*	2	1	2	100
Carex acuta L.	1	+	2	100
Elymus repens (L.) Gould subsp. *repens*	1	+	2	100
Convolvulus arvensis L.	1	.	1	50
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	+	.	1	50
Rubus ulmifolius Schott		1	1	50

Table S18. *Phalaridetum arundinaceae typicum*, *Phalaridetum arundinaceae alopecuretosum bulbosi.*

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30*	31	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	147	152	156	157	158	149	155	153	154	151	148	150	143	145	146	144	129	131	136	132	133	134	135	137	142	138	139	140	128	130	141		
Elevation (m a.s.l.)	756	756	794	777	777	756	794	795	780	780	756	756	756	756	756	776	777	795	780	777	777	777	777	777	777	779	781	781	777	778	777		
Aspect	-	-	-	NNE	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	95	100	100	100	95	100	90	80	100	100	100	100	100	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Area (m^2)	25	25	50	20	15	25	50	25	20	10	20	20	20	40	40	20	20	25	100	100	100	100	100	100	100	100	100	100	200	100	100		
Locality	PC	PC	R	An	An	PC	R	R	Ar	Ar	PC	PC	PC	PC	PC	An	An	R	Ar	An	An	An	An	An	An	Ar	Ar	Ar	An	An	An		
Char. species of *Phalaridetum arundinaceae* association																																	
Phalaris arundinacea L. subsp. *arundinacea*	4	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	5	31	100
Differential species of *Phalaridetum arundinaceae alopecuretosum bulbosi* subassociation																																	
Galium debile Desv.	.	.	.	+	.	.	+	.	.	.	+	.	.	+	+	3	.	1	+	1	1	+	1	+	+	.	+	+	.	3	2	18	53
Alopecurus bulbosus Gouan subsp. *bulbosus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	2	3	3	2	1	+	+	3	3	3	+	+	.	14	47
Trifolium resupinatum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	2	3	1	+	.	1	3	2	+	+	1	13	47
Centaurea jacea L. subsp. *jacea*	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	+	1	1	+	.	+	1	+	2	1	2	2	14	44
Alopecurus rendlei Eig	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	3	.	+	1	+	.	1	.	3	2	4	3	5	4	4	13	41
Oenanthe fistulosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	1	1	2	3	+	2	.	+	.	+	.	1	.	11	38
Plantago lanceolata L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	+	+	1	1	+	.	.	+	.	+	1	+	11	38
Species of the *Carex acuta* variant																																	
Carex acuta L.	.	+	+	.	.	.	1	.	.	.	.	.	.	.	+	3	4	2	+	5	4	5	2	3	.	.	.	.	+	1	.	15	50
Char. species of the *Phragmition communis* alliance and higher syntaxa																																	
Galium palustre L. subsp. *elongatum* (C.Presl) Lange	+	3	.	.	.	+	.	.	.	.	+	+	.	+	+	.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.	9	28
Lythrum salicaria L.	+	+	.	.	.	1	.	+	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	25
Mentha aquatica L. subsp. *aquatica*	+	+	.	.	.	.	.	1	.	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	6	22
Scutellaria galericulata L.	+	+	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	16
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	+	.	.	3	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	13
Eleocharis palustris (L.) Roem. & Schult. subsp. *palustris*	.	+	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	9
Alisma plantago-aquatica L.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	9
Lycopus europaeus L.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6
Rorippa amphibia (L.) Besser	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6
Equisetum fluviatile L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6
Schoenoplectus lacustris (L.) Palla	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Carex elata All. subsp. *elata*	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Veronica beccabunga L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	3
Ingressive species from *Molinio-Arrhenatheretea* class																																	
Ranunculus repens L.	1	2	.	.	.	.	.	+	.	.	.	.	+	+	1	+	+	1	1	1	1	1	2	2	.	+	3	2	+	1	.	20	66
Gratiola officinalis L.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	2	.	+	1	2	1	2	1	.	+	.	2	+	.	.	12	44
Carex otrubae Podp.	4	2	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	1	1	+	.	.	.	8	28
Lotus corniculatus L. subsp. *corniculatus*	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	+	+	.	.	.	.	.	+	+	+	8	28
Poa pratensis L. subsp. *pratensis*	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	4	.	2	1	.	.	1	8	25
Thalictrum lucidum L.	.	.	3	+	1	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	7	22
Potentilla reptans L.	.	.	2	.	.	.	1	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	+	.	.	.	+	+	+	7	19
Ranunculus velutinus Ten.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	r	+	5	16
Bromus racemosus L. subsp. *racemosus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	+	.	.	4	16
Lysimachia vulgaris L.	+	.	+	.	.	.	.	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	16
Lolium perenne L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	.	.	.	3	13
Rumex acetosa L. subsp. *acetosa*	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	4	13

Table S18. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30*	31		
Relevé number in the dendrogram (Fig. 2)	147	152	156	157	158	149	155	153	154	151	148	150	143	145	146	144	129	131	136	132	133	134	135	137	142	138	139	140	128	130	141		
Elevation (m a.s.l.)	756	756	794	777	777	756	794	795	780	780	756	756	756	756	756	776	777	795	780	777	777	777	777	777	777	779	781	781	777	778	777		
Aspect	-	-	-	NNE	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	100	95	100	100	100	95	100	90	80	100	100	100	100	100	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Area (m^2)	25	25	50	20	15	25	50	25	20	10	20	20	20	40	40	20	20	25	100	100	100	100	100	100	100	100	100	100	200	100	100		
Locality	PC	PC	R	An	An	PC	R	R	Ar	Ar	PC	PC	PC	PC	PC	An	An	R	Ar	An	An	An	An	An	An	Ar	Ar	Ar	An	An	An	No. of occurrences	Frequency (%)
Poa trivialis L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	9
Carex hirta L.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	9
Agrostis stolonifera L. subsp. *stolonifera*	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	9
Juncus inflexus L. subsp. *inflexus*	.	.	.	.	.	.	.	.	.	1	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	9
Galega officinalis L.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	9
Galium album Mill. subsp. *album*	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6
Rumex crispus L.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6
Anthoxanthum odoratum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	6
Trifolium dubium Sibth.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	6
Lychnis flos-cuculi L. subsp. *flos-cuculi*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	2	3
Deschampsia cespitosa (L.) P.Beauv. subsp. *cespitosa*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	2	6
Trifolium pratense L. subsp. *pratense*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	2	3
Rorippa sylvestris (L.) Besser subsp. *sylvestris*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	2	9
Hordeum secalinum Schreb.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	+	2	6
Trifolium repens L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	6
Dactilis glomerata L. subsp. *glomerata*	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Dactylorhiza incarnata (L.) Soó subsp. *incarnata*	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Rumex conglomeratus Murray	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Valeriana officinalis L. subsp. *officinalis*	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Lotus tenuis Waldst. & Kit. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Epilobium parviflorum Schreb.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
Cynosurus cristatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	6
Lolium arundinaceum (Schreb.) Darbysh. subsp. *arundinaceum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	6
Holcus lanatus L. subsp. *lanatus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	3
Barbarea vulgaris R.Br.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	3
Bellevalia romana (L.) Sweet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	3
Other species																																	
Cirsium arvense (L.) Scop.	r	.	.	+	1	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	16
Ranunculus sardous Crantz	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	+	.	+	.	.	.	+	.	5	19
Taraxacum sect. *Palustria* (H.Lindb.) Dahlst.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	+	4	13
Persicaria lapathifolia (L.) Delarbre subsp. *lapathifolia*	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	9
Convolvulus arvensis L.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6

Sporadic taxa: rel. 4 - *Elymus repens* (L.) Gould subsp. *repens*, +; *Conium maculatum* L. subsp. *maculatum*, +; rel 5 - *Aristolochia rotunda* L. subsp. *rotunda*, +; *Cirsium vulgare* (Savi) Ten. subsp. *vulgare*, +; rel. 12 - *Sonchus asper* (L.) Hill subsp. *asper*, +; rel. 29 - *Cruciata laevipes* Opiz, +; *Carex flacca* Schreb. subsp. *erythrostachys* (Hoppe) Holub, +; *Geranium dissectum* L., +; *Taraxacum officinale* (group), +.

Table S19. *Carex otrubae* community, *Gratiola officinalis* community, *Oenantho aquaticae-Rorippetum amphibiae*.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No. of occurrences	Frequency (%)
Relevé number in the dendrogram (Fig. 2)	101	103	102	104	105	61	62	65	63	64	66	50	52	51	53		
Elevation (m a.s.l.)	780	781	780	779	781	791	791	781	781	781	780	779	780	780	756		
Aspect	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Slope angle (°)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total cover (%)	100	95	80	100	100	98	98	100	100	100	100	50	100	80	100		
Area (m²)	5	5	15	5	5	15	15	6	5	6	5	10	10	20	50		
Locality	Ar	Ar	Ar	Ar	Ar	R	R	Ar	Ar	Ar	Ar	Ar	Ar	Ar	PC		
Species of *Carex otrubae* community																	
Carex otrubae Podp.	5	5	4	5	5	.	.	+	1	.	.	1	.	1	+	10	67
Species of *Gratiola officinalis* community																	
Gratiola officinalis L.	2	+	+	+	+	2	2	5	5	5	5	2	.	2	.	13	87
Char. species of *Oenantho aquaticae-Rorippetum amphibiae* association																	
Rorippa amphibia (L.) Besser	.	.	.	.	.	.	.	.	.	.	.	2	4	2	5	4	27
Species of *Potentillion anserinae* and higher syntaxa																	
Ranunculus repens L.	1	.	+	.	.	1	+	.	.	+	.	2	.	.	+	7	47
Galium album Mill. subsp. *album*	.	+	.	.	.	.	.	.	+	+	+	.	.	.	.	4	27
Mentha pulegium L. subsp. *pulegium*	.	.	.	.	.	2	2	3	+	.	.	.	.	.	.	4	27
Galega officinalis L.	.	.	.	.	.	.	.	+	.	+	1	.	.	.	.	3	20
Carex hirta L.	.	.	1	+	.	.	.	.	.	+	.	.	.	.	.	3	20
Carex panicea L.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	2	13
Oenanthe fistulosa L.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	2	13
Ranunculus flammula L.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	2	13
Dactylorhiza incarnata (L.) Soó subsp. *incarnata*	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	2	13
Rumex acetosa L. subsp. *acetosa*	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Equisetum palustre L.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Carex flacca Schreb. subsp. *erythrostachys* (Hoppe) Holub	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	7
Plantago lanceolata L.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7
Rumex conglomeratus Murray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	7
Char. species of *Phragmito-Magnocaricetea* class																	
Phalaris arundinacea L. subsp. *arundinacea*	.	.	.	.	.	2	1	.	1	.	.	.	3	.	.	4	27
Alisma plantago-aquatica L.	.	.	.	.	.	.	.	.	.	.	.	3	.	1	+	3	20
Myosotis scorpioides L. subsp. *scorpioides*	.	.	.	.	.	.	.	.	.	.	.	+	3	2	.	3	20
Mentha aquatica L. subsp. *aquatica*	.	.	.	.	.	.	.	.	.	.	.	.	1	4	3	3	20
Typha latifolia L.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	+	3	20
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+	3	20
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	2	13
Schoenoplectus lacustris (L.) Palla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	7
Carex acuta L.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	7
Other species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Ranunculus trichophyllus Chaix	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	7
Callitriche stagnalis Scop.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	7
Myriophyllum verticillatum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	7
Taraxacum sect. *Palustria* (H.Lindb.) Dahlst.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7

Table S20. List of the plant communities found in the current research and of those found by other authors in the past. The second column indicates whether the listed syntaxa are newly found (N), have been found in the past and are confirmed by our research (C), have been found in the past and are not confirmed by our research (NC), have been found for the first time by other authors after our survey (NOA). In the third column, for the syntaxa deemed habitats of community interest, the code of the habitat following the Annex I of the 92/43/EEC Directive is indicated. In the fourth column, the locality (An – Piano di Annifo; Co – Piani di Colfiorito; PC – Palude di Colfiorito; R – Piano di Ricciano) and the year when the relevés were carried out and the citations of papers that referred to the syntaxon found in the past are reported.

Class	Order	Alliance	Association and lower-rank syntaxa	Status	Habitat of community interest (Annex I, 92/43/EEC Directive)[1]	Literature
CHARETEA FRAGILIS Fukarek ex Krausch 1964	*CHARETALIA HISPIDAE* Sauer ex Krausch 1964	**Charion fragilis** Krausch 1964	*Charetum fragilis* Corillion 1957	NC	3140	PC, 1966 (Pedrotti 2019)
		Charion vulgaris (Krause ex Krause et Lang 1977) Krause 1981	*Charetum vulgaris* Corillion 1957	NC	3140	PC, 1967 (Pedrotti 2019)
	NITELLETALIA FLEXILIS W. Krause 1969	**Nitellion flexilis** W. Krause 1969	*Nitelletum mucronatae* Corillion et Guerlesquin 1972	NC	3140	PC, 1968 (Pedrotti 2019)
LEMNETEA de Bolós et Masclans 1955	*LEMNETALIA MINORIS* Tüxen ex O. Bolòs et Masclans 1955	**Lemnion minoris** Tüxen ex O. Bolòs et Masclans 1955	*Lemnetum minoris* von Soó 1927	NC	3150	PC, 1977 (Pedrotti 1979)
			Ricciocarpetum natantis Tüxen 1974	NC	3150	PC, 1977 (Pedrotti 1979), PC, 1977 (Pedrotti 1979); Co, 1991 (Aleffi and Cortini Pedrotti 1995)
		Utricularion vulgaris Passarge 1964	*Utricularietum australis* Müller et Görs 1960	NC	3150	PC, 1967 (sub *Utricularietum neglectae* in Pedrotti 2019)
POTAMOGETONETEA Klika in Klika et Novák 1941	*POTAMOGETONETALIA* Koch 1926	**Potamogetonion** Libbert 1931	*Potamogetono pectinati-Myriophylletum spicati* Rivas Goday 1964	C	3150	PC, 1967 (sub *Myriophylletum spicati*, Pedrotti 2019). Orsomando (2000, 2002) referred generically to a vegetation dominated by *Myriophyllum spicatum* and *M. verticillatum* (observation not supported by phytosociological relevès).
			Myriophylletum verticillati Gaudet ex Šumberová in Chytrý 2011	C	3150	PC, 1967 (Pedrotti 2019); Orsomando (2000, 2002) referred generically to a vegetation dominated by *Myriophyllum spicatum* and *M. verticillatum* (observation not supported by phytosociological relevès).
			Myriophyllo-Potamogetonetum lucentis Soó 1934	NC	3150	PC, 1967 (sub *Myriophyllo-Potametum lucentis* in Pedrotti 2019)
			Myriophyllo-Potamogetonetum lucentis Soó 1934 *nymphaeetosum albae* Pedrotti 2019	NC	3150	PC, 1967 (sub *Myriophyllo-Potametum lucentis nymphaeetosum* in Pedrotti 2019); referred by Pedrotti (1975) to the *Potametum lucentis nymphaeetosum* subassociation
		Nymphaeion albae Oberd. 1957	*Nymphaeetum albae* Vollmar 1947	N	3150	Ballelli et al. (2001) and Orsomando (2000, 2002) reported a *Nymphaea alba* community (*Nymphaeion albae*). These observations were not supported by phytosociological relevés.
			Persicaria amphibia community	C	3150	PC, 2002 (Ballelli et al. 2001; Orsomando 2002, not supported by phytosociological relevés)
		Ranunculion aquatilis Passarge ex Theurillat in Theurillat et al. 2015	*Potamogetono crispi-Ranunculetum trichophylli* Imchenetzky 1926	N	3260	
			Callitriche stagnalis community	N	3260	
			Veronico beccabungae-Callitrichetum stagnalis Müller 1962	NOA	3260	PC, 2019 (Pedrotti 2019)
			Ranunculus trichophyllus community	NC	3260	PC, 1990-1991 (Buchwald 1994); PC (Pedrotti 2019, not supported by phytosociological relevés). Probably, this community is to be referred to the *Potamogetono crispi-Ranunculetum trichophylli*.
BIDENTETEA Tx. et al. ex von Rochow 1951	*BIDENTETALIA* Br.-Bl. et Tx. ex Klika et Hadač 1944	**Bidention tripartitae** Nordhagen ex Klika et Hadač 1944	*Bidentetum tripartitae* Miljan 1933	C	3270	PC, 1967, 2020 (Pedrotti 2019; Pedrotti and Murrja 2020); referred by Pedrotti (1975) and Orsomando (2000) to the Bidens tripartita community
			Bidentetum tripartitae Miljan 1933 *Persicaria lapathifolia* variant	NOA	3270	PC, 2020 (Pedrotti and Murrja 2020)
			Bidentetum tripartitae Miljan 1933 *Chenopodiastrum murale* variant	NOA	3270	PC, 2020 (Pedrotti and Murrja 2020)
			Alopecuretum aequalis Müller 1975	NC	3270	PC, 1967 (Pedrotti 2019); referred by Pedrotti (1975) to the *Rumici-Alopecuretum geniculati*
		Chenopodion rubri (Tüxen in Poli et J. Tüxen 1960) Hilbig et Jage 1972	*Polygono lapathifolii-Xanthietum italici* Pirola et Rossetti 1974	N	3270	
ISOËTO-NANOJUNCETEA Br.-Bl. et Tüxen ex Westhoff, Dijk et Passchier 1946	*NANOCYPERETALIA FLAVESCENTIS* Klika 1935	**Nanocyperion flavescentis** Koch ex Libbert 1932	*Juncetum bufonii* Felföldy 1942	NC	3170	PC, 1968 (Pedrotti 2019)

Table S20. Continuation.

			Glycerietum maximae Nowiński 1930 corr. Šumberová, Chytrý et Danihelka in Chytrý 2011	C	PC, 1963, 2020 (Pedrotti 2019; Pedrotti and Murrja 2020); PC, 1990-1991 (Buchwald 1994); PC (Orsomando 2000, 2002, not supported by phytosociological relevés).
			Iridetum pseudacori Eggler 1933 ex Brzeg et M. Wojterska 2001	N	
			Phalaridetum arundinaceae Libbert 1931 *typicum*	C	PC, 1967-1968, 2020 (Pedrotti 2019; Pedrotti and Murrja 2020); PC (Orsomando 2000, 2002, not supported by phytosociological relevés); Pedrotti (1975) reported also the *Phalaridetum arundinaceae scirpetosum* subassociation and a *Phragmites australis* variant. R, 2002 (Tardella et al. 2002, not supported by phytosociological relevés).
			Phalaridetum arundinaceae Libbert 1931 *alopecuretosum bulbosi* subass. nova	N	
			Phalaridetum arundinaceae Libbert 1931 *alopecuretosum bulbosi* subass. nova *Carex acuta* variant	N	
	PHRAGMITETALIA Koch 1926	**Phragmition communis** Koch 1926	*Phragmitetum australis* Savič 1926	C	PC, 1967 (Pedrotti 2019); PC (Orsomando 2000, 2002 - not supported by phytosociological relevés); R, 2002 (Tardella et al. 2002, not supported by phytosociological relevés); PC, 2014 (Lastrucci et al. 2017a).
			Phragmitetum australis Savič 1926 *Myriophyllum spicatum* variant	NOA	PC, 2014 (Lastrucci et al. 2017a)
			Phragmitetum australis Savič 1926 *Calystegia sepium* variant	NOA	PC, 2014 (Lastrucci et al. 2017a)
			Phragmitetum australis Savič 1926 *Urtica dioica* variant	NOA	PC, 2014 (Lastrucci et al. 2017a)
			Phragmitetum australis Savič 1926 *Schoenoplectus lacustris* variant	NOA	PC, 2014 (Lastrucci et al. 2017a)
			Cyperetum longi (Micevski 1957) Micevski 1963	N	
			Schoenoplectetum lacustris Chouard 1924	C	PC, 1967 (sub Scirpetum lacustris, Pedrotti 2019 and Pedrotti and Murrja 2020); PC, 1990-1991 (sub idem, Buchwald 1994); PC (sub idem, Orsomando 2000, 2002, not supported by phytosociological relevés)
			Typhetum latifoliae Nowiński 1930	C	PC, 1966 (Pedrotti 2019); PC (Orsomando 2000, 2002; Ballelli et al. 2001; not supported by phytosociological relevés)
			Typhetum angustifoliae Pignatti 1953	NC	PC, 1966 (Pedrotti 2019); PC (Ballelli et al. 2001, not supported by phytosociological relevés)
PHRAGMITO-MAGNOCARICETEA Klika in Klika et Novák 1941			*Caricetum gracilis* Savič 1926	C	PC, 1967 (Pedrotti 2019); Pedrotti (1975) reported also *Caricetum gracilis phalaridetosum* subassociation and a *Phragmites australis* variant. R, 2002 (Tardella et al. 2002 referred generically to a vegetation dominated by *Carex acuta* and *C. vesicaria*, observation not supported by phytosociological relevès).
	MAGNOCARICETALIA Pignatti 1953	**Magnocaricion gracilis** Géhu 1961	*Caricetum ripariae* Máthé et Kovács 1959	C	R, 2002 (Tardella et al. 2002 referred generically to a vegetation dominated by *Carex elata* and *C. riparia* observation not supported by phytosociological relevès).
			Caricetum vesicariae Chouard 1924	N	
		Magnocaricion elatae Koch 1926	*Caricetum elatae* Koch 1926	NC	PC, 1967 (Pedrotti 2019); R, 2002 (Tardella et al. 2002 referred generically to a vegetation dominated by *Carex elata* and *C. riparia* observation not supported by phytosociological relevès).

Table S20. Continuation.

PHRAGMITO-MAGNOCARICETEA Klika in Klika et Novák 1941	*OENANTHETALIA AQUATICAE* Hejný ex Bálatová-Tuláčková, Mucina, Ellmauer et Wallnöfer in Grabherr et Mucina 1993	**Eleocharito palustris-Sagittarion sagittifoliae** Passarge 1964	*Eleocharitetum palustris* Savič 1926	C		PC, 1967 (Pedrotti 2019); PC (Orsomando 2000; Ballelli et al. 2001; Orsomando 2002 - not supported by phytosociological relevés); R, 2002 (Tardella et al. 2002, not supported by phytosociological relevés).
			Oenantho aquaticae-Rorippetum amphibiae Lohmeyer 1950	C		PC (Orsomando 2002, not supported by phytosociological relevés)
			Oenanthetum aquaticae Soó ex Nedelcu 1973	NC		PC, 1968 (Pedrotti 2019); previously referred by Pedrotti (1975) to the *Oenantho-Rorippetum*
			Oenanthetum aquaticae Soó ex Nedelcu 1973 *rorippetosum amphibiae* Pedrotti 2019	NC		PC, 1968 (Pedrotti 2019); previously referred by Pedrotti (1975) to the *Oenantho-Rorippetum rorippetosum amphibiae* subassociation and the *Glyceria plicata* variant
			Rorippa amphibia community	NOA		PC, 2020 (Pedrotti and Murrja 2020)
			Butometum umbellati Philippi 1973	NC		PC, 1967 (Pedrotti 2019)
	NASTURTIO-GLYCERIETALIA Pignatti 1953	**Glycerio-Sparganion** Br.-Bl. et Sissingh in Boer 1942	*Beruletum erectae* Roll 1938	N		
			Glycerietum notatae Kulczyński 1928	C		PC, 1990-1991 (Buchwald 1994)
			Glycerietum fluitantis Nowiński 1930	NC		PC, 1967 (Pedrotti 2019)
			Rorippo ancipitis-Catabrosetum aquaticae (Oberdorfer 1957) Müller et Görs 1961	N		
			Helosciadietum nodiflori Maire 1924	C		PC, 1967 (Pedrotti 2019); PC, 1990-1991 (sub *Apietum nodiflori*, Buchwald 1994)
			Nasturtietum officinalis Gilli 1971	C		PC, 1967 (Pedrotti 2019); PC, 1990-1991 (Buchwald 1994)
			Sparganietum erecti Roll 1938	C		PC, 1963 (Pedrotti 2019); PC (Orsomando 2002, not supported by phytosociological relevés)
			Veronica anagallis-aquatica subsp. *anagallis-aquatica* community	N		
			Veronico-Apietum submersi Buchwald 1992	NC		Co, 1967 (Pedrotti 2019); PC, 1990-1991 (Buchwald 1994)
SCHEUCHZERIO PALUSTRIS-CARICETEA NIGRAE nom. mut. propos. ex Steiner 1992	*CARICETALIA DAVALLIANAE* Br.-Bl. 1949	**Caricion davallianae** Klika 1934	*Eriophorum latifolium* community	NC	7230	PC, 1967 (Pedrotti 2019); referred by Pedrotti (1975) to the *Eriophoretum latifolii* association
			Carex panicea community	NC	7230	PC, 1968 (Pedrotti 2019)
			Juncus subnodulosus community	NC	7230	PC, 1968 (Pedrotti 2019)
MOLINIO-ARRHENATHERETEA Tüxen 1937	*TRIFOLIO-HORDEETALIA* Horvatić 1963	**Ranunculion velutini** Pedrotti 1978	*Deschampsio-Caricetum distantis* Pedrotti 1976	C	6510	PC, 1967 (Pedrotti 2019); PC (Orsomando 2002, not supported by phytosociological relevés); R, 2002 (Tardella et al. 2002, not supported by phytosociological relevés).
			Hordeo-Ranunculetum velutini Pedrotti 1976	C	6510	An, PC, R, 1963 (Pedrotti 1976, 2019); PC (Orsomando 2000, 2002, not supported by phytosociological relevés); R, 2002 (Tardella et al. 2002, not supported by phytosociological relevés).
	POTENTILLO-POLYGONETALIA avicularis Tüxen 1947	**Potentillion anserinae** Tüxen 1947	*Carex hirta* community	N		
			Carex otrubae community	N		
			Galega officinalis community	C		PC (Pedrotti 1975; Orsomando 2000, not supported by phytosociological relevés)
			Gratiola officinalis community	N		
			Epilobium hirsutum community	N		
			Potentilla reptans community	N		
			Ranunculo sardoi-Agrostietum stoloniferae Pedrotti 2019	NC		PC, 1967 (Pedrotti 2019); referred by Pedrotti (1975) to the *Rorippo-Agrostidetum albae* association, with the *Poa trivialis* and *Ranunculus sardous* variants
			Cirsio triumfettii-Galegetum officinalis Venanzoni et Gigante 2000	NC		PC, 1965 (Pedrotti 2019; referred by Pedrotti (1975) to the *Galega officinalis* community; Pedrotti and Murrja 2020)
			Agrostio stoloniferae-Ranunculetum repentis (Knapp ex Oberd. 1957) Oberd. et al. 1967	NC		PC, 1965 (Pedrotti 2019); referred by Pedrotti (1975) to the *Ranunculus repens* community
			Alopecuro bulbosi-Menthetum pulegii (de Foucault 1984) Julve 2011	NC		R, 1963 (Pedrotti 2019)
		Mentho longifoliae-Juncion inflexi T. Müller et Görs ex de Foucault 2009	*Carici otrubae-Juncetum inflexi* Minissale et Spampinato 1985	N		

Table S20. Continuation.

EPILOBIETEA ANGUSTIFOLII Tx. et Preising ex von Rochow 1951	*ARCTIO LAPPAE-ARTEMISIETALIA VULGARIS* Dengler 2002	**Balloto-Conion maculati** S. Brullo et Marcenò 1985	*Urtico dioicae-Sambucetum ebuli* (Br.-Bl. in Br.-Bl., Gajewski, Wraber et Wa1as 1936) Br.-Bl. in Br.-Bl., Roussine et Nègre 1952	C	PC (Pedrotti 1975, 2019, not supported by phytosociological relevés)
STELLARIETEA MEDIAE Tüxen, Lohmeyer & Preising ex von Rochow 1951	*CHENOPODIETALIA MURALIS* Braun-Blanquet in Braun-Blanquet, Gajewski, Wraber et Walas 1936	**Chenopodion muralis** Braun-Blanquet in Braun-Blanquet, Gajewski, Wraber et Walas 1936	*Chenopodietum muralis* Braun-Blanquet in Braun-Blanquet, Gajewski, Wraber et Walas 1936	NOA	PC, 2020 (Pedrotti and Murrja 2020)

[1] 3140 - Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.; 3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation; 3170* - Mediterranean temporary ponds; 3260 - Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; 3270 - Rivers with muddy banks with *Chenopodion* rubri p.p. and *Bidention* p.p. vegetation; 6510 - Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*); 7230 - Alkaline fens

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