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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, rec-

reation (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 eleag-*

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

nos, *Fraxinus ornus* accompanied by *Hippophaë fluviatilis*, *Ligustrum vulgare* and many other shrubs, along with single 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.

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

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

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	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

from the Hungarian side of the River Drava along the border with Croatia, and assigned to *Alnion glutinosae* (*Alnetea glutinosae*).

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

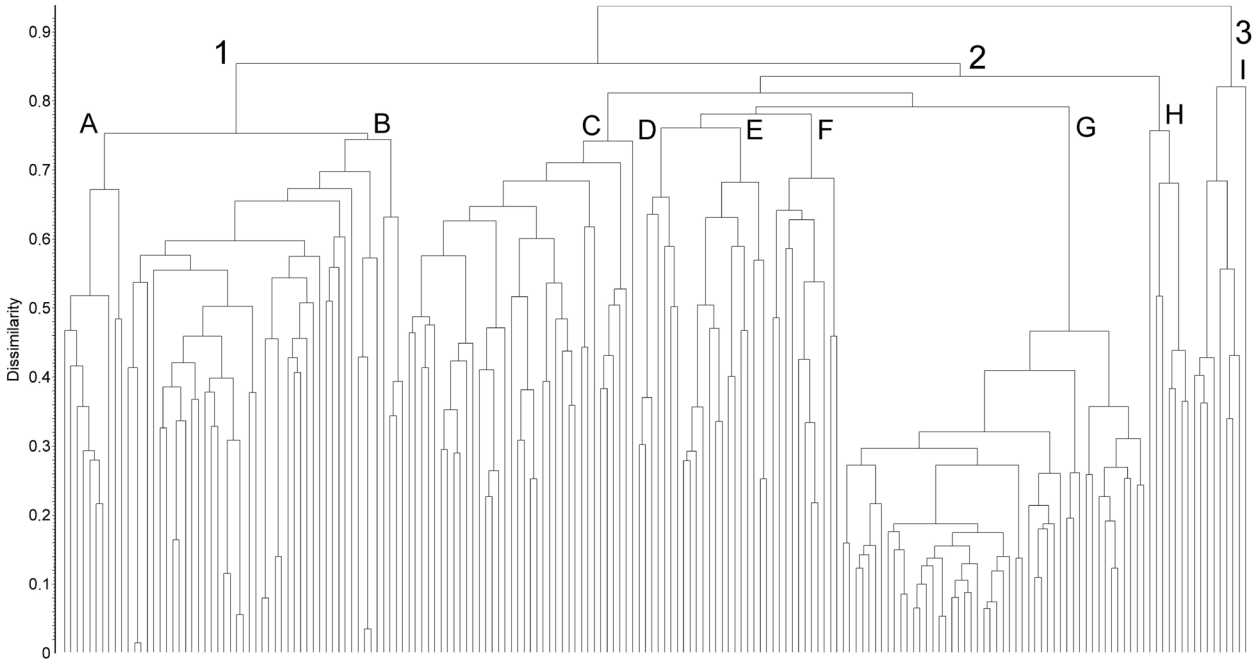

Figure 1. Cluster analysis (cover data, Similarity ratio, WPGMA) of alluvial/waterside woods rich in *Ulmus minor* from the central-western Po Plain assigned in the literature to *Alno-Padion* and from the Karst area, riverine woods of *Lamio-Ulmetum* and *Dioscoreo-Populetum*, alluvial oak-hornbeam 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).

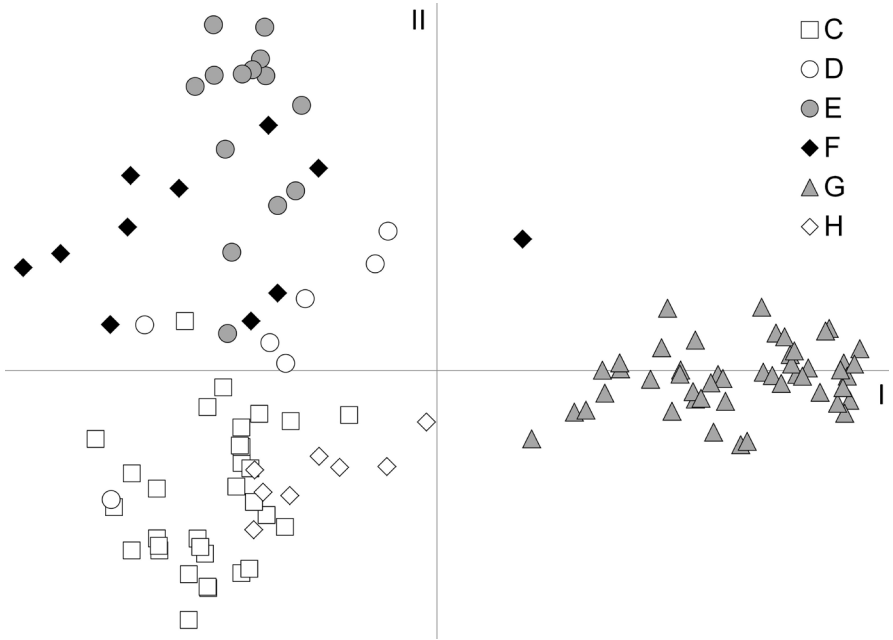

Figure 2. PCA of the relevés of cluster 2 of the dendrogram of Fig. 1 (First component: 20.34 % of total variance, second component: 10.76 %). Relevés are grouped and labelled according to the dendrogram of Fig. 1. C: *Vinco minoris-Ulmetum minoris ass. nov*.; D: *Lamio-Ulmetum minoris*; E: *Rhamno catharticae-Ulmetum 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 oxycarpa*e (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 oxycarpa*e 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 oxycarpa*e), 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-

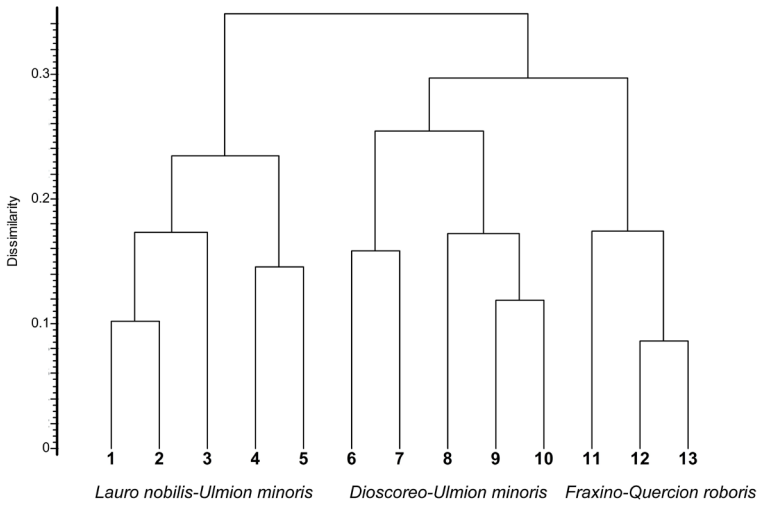

Figure 3. Cluster analysis (frequency data, Similarity ratio, Ward's method) of synthetic tables of Italian and European alluvial/waterside *Ulmus minor*-rich woods included in Tab. 7. Labels of synthetic tables as in Tab. 7.

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. riviniana* 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.

	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**	***63.0***	**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	.	.	***29.0***	**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.

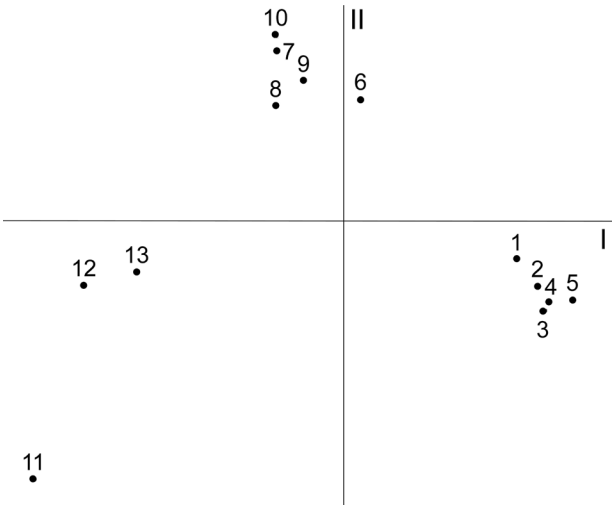

Figure 4. PCA of synthetic tables of Italian and European alluvial/waterside *Ulmus minor*-rich woods included in Tab. 7. (First component: 29.05 % of total variance, second component: 14.91 %). Labels of synthetic tables as in Tab. 7.

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 oxycarpa*e, described from the same karstic wetlands (Poldini and Sburlino 2018) and *Cladio-Fraxinetum oxycarpa*e (*Frangulo-Fraxinion oxycarpa*e). 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 (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.
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*

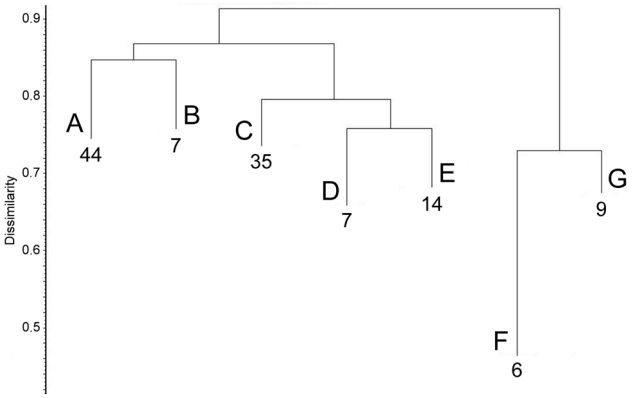

Figure 5. Cluster analysis (cover data, Similarity ratio, WPGMA) of relevés of alluvial/waterside Po Plain and karstic *Ulmus minor*-rich forests and *Fraxinus angustifolia* subsp. *oxycarpa* swamp forests of *Frangulo-Fraxinion*. Simplified dendrogram with major groups of relevés and number of relevés 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).

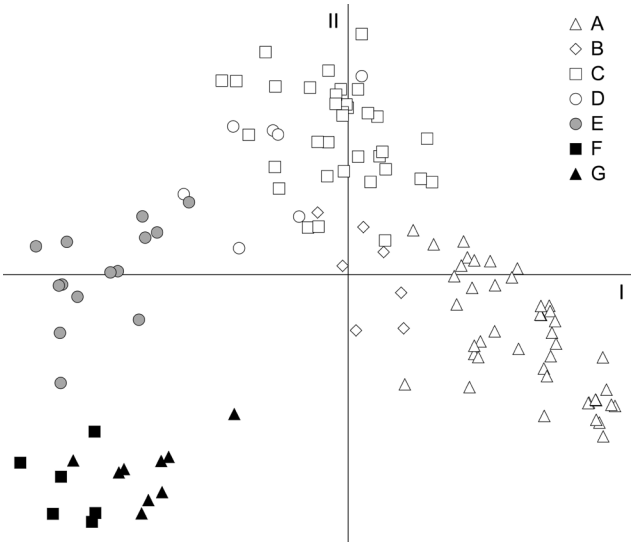

Figure 6. PCA of relevés of alluvial/waterside Po Plain and karstic *Ulmus minor*-rich forests and *Fraxinus angustifolia* subsp. *oxycarpa* swamp forests of *Frangulo-Fraxinion* (First component: 18.31 % of total variance, second component: 11.83 %). Relevés are grouped and labelled according to the 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*, *Convolvolus 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*	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	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 ac-

tions 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.

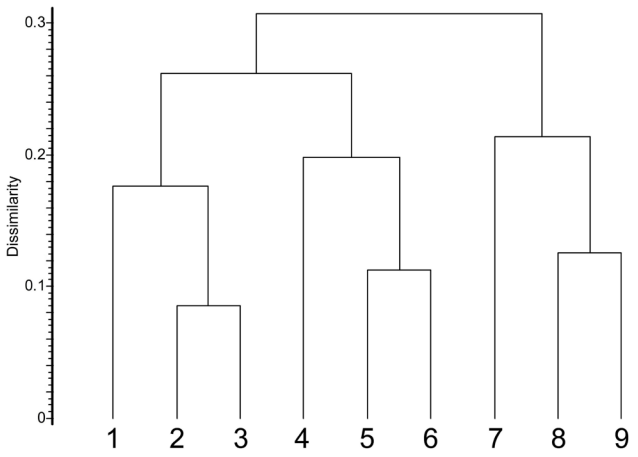

Figure 7. Cluster analysis (frequency data, Similarity ratio, Ward's method) of synthetic tables of *Salicetum triandrae* from different parts of Europe included in Tab. 11. Labels of synthetic tables as in Tab. 11.

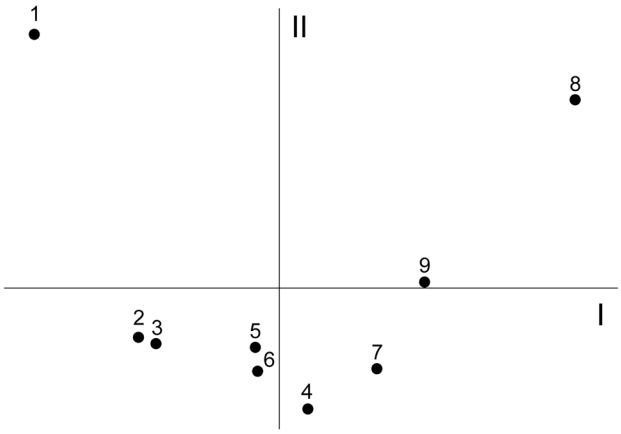

Figure 8. PCA of synthetic tables of *Salicetum triandrae* from different parts of Europe included in Tab. 11. (First component: 31.13 % of total variance, second component: 21.89 %). Labels of synthetic tables as in Tab. 11.

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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Statements

The authors have no funding to report. The authors have declared that no competing interests exist.

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

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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: Go-

lena 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. (+), *Valeriana 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/pls2020572/01.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.

Link: https://doi.org/10.3897/pls2020572/01.suppl2

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.

Link: https://doi.org/10.3897/pls2020572/01.suppl3