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Vegetation and habitat of conservation interest of the lake Acquato (Grosseto – Central Italy)

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Abstract
The vegetation of the Mediterranean wetland of the lake Acquato (Grosseto Province, southern Tuscany) was studied according to the phytosociological method. The study put in evidence the occurrence of hydrophytic, helophytic, perennial wet meadow and annual hygrophilous communities, respectively belonging to the following classes: *Lemnetea minoris*, *Potametea pectinati*, *Phragmito-Magnocaricetea*, *Agrostietea stoloniferae*, *Bidentetea tripartitae* and *Isoëto-Nanojuncetea*. Some vegetation types are reported for the first time for Italy. Two habitats of conservation value according to the 92/43/CEE Directive Habitats have been identified.

Key words: annual hygrophilous coenoses, aquatic vegetation, helophytic communities, Mediterranean wetlands, phytosociology, southern Tuscany.

Introduction

The high conservation importance of wetlands in the Mediterranean basin was recognised in several recent studies (Benavent-González *et al*., 2014; García-Madrid *et al*., 2014; Bagella *et al*., 2016; Angiolini *et al*., 2017; Tornero *et al*., 2018). Biondi *et al*. (2012) and Gigante *et al*. (2016, 2018) emphasized the central rule of phytosociology for the individuation of habitats of conservation importance and their monitoring. Then the phytosociological approach, including floristic, ecological, syndinamic and phytogeographic components (see Biondi, 2005) can be very helpful in the study of the high biodiversity of these habitats. The phytosociological approach applied in several recent studies on Tuscan wetlands allowed to identify new or rare vegetation types and a large number of habitats of conservation interest (e.g. Lastrucci *et al*., 2010a, 2010b, 2012, 2014, 2016, 2017a; Mereu *et al*., 2012), leading to the production of cartographic documents representing relevant for the habitat management and the monitoring planning (Viciani *et al*., 2017). The present contribution is part of a series of surveys focused on the wetland vegetation of the southern Tuscan Maremma, in the province of Grosseto, with particular reference to the Capalbio area, where previous studies put in evidence the presence of rare and interesting phytocoenoses (Lastrucci *et al*., 2007).

The study area: ecological features and botanical knowledge

The lake Acquato (UTM 32T: 4706600N; 701680E) is located in a small depression between the hills at north-east of Poggio Monteti (Grosseto province); according to Pesaresi *et al*. (2017) the study area is included in the Mediterranean Macrobioclimate. The lake is part of the Natura 2000 network as a Site of Community Importance, named "Lago Acquato, Lago San Floriano" (IT51A0030), recently approved as a Special Area of Conservation. As for other wetlands of the Capalbio area, also for this basin a karst origin can be hypothesized (Tomei *et al*, 1986; Guazzi & Tomei, 1996). Several authors (Mori, 1932; Tomei *et al*., 1986; Guazzi & Tomei, 1996) underlined the absence of a real tributary, so that the water supply comes essentially from rainwater and, at lesser extend, from a small spring in the south-east shore. The high fluctuation of the seasonal water level, depending on rainfall and temperatures, and the long-term changes of the biotope, already evidenced by Mori (1932) and Guazzi & Tomei (1996), reverberate in more or less long periods of basin drainage. During our surveys (until the summer 2018), the presence of few centimetres of water in the small open spaces between the marsh vegetation was observed until the early summer, fast decreasing to the complete drying in late summer.

The lake is subject to a strong anthropogenic disturbance due the presence of cultivated areas around the wetland (Tomei *et al*., 2001). This implies an intense human management such as the recurrent cutting of vegetation or the creation of paths for heavy vehicles.

A small-size pond surrounded by a thicket of *Fraxinus angustifolia* Vahl subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso and *Populus nigra* L.

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is present in the south-western part of the wetland. Although the pond depth decreased during the summer, it never reached the total drainage during our surveys.

The botanical knowledge of the study area was almost exclusively floristic, thanks to the Sommier collections (see Sommier, 1892a, 1892b) and to the more recent contributions by various botanists (Tomei *et al*., 1986; Tomei & Guazzi, 1996; Guazzi & Tomei, 1996: Tomei *et al*., 2001); in addition, an overall floristic contribution to the flora of the Tuscan Maremma, also reporting data about the lake Acquato, was published by Selvi (2010).

Material and methods

The Lake Acquato vegetation was studied through the phytosociological method (Braun-Blanquet, 1932; Biondi, 2011; Pott, 2011). A total of 46 relevés were carried out. The phytocoenoses were sampled according to the principle of "local and physiognomic microhomogeneity" (Géhu, 1988).

The matrix of relevés, previously transformed according to the ordinal scale proposed by van der Maarel (1979), was subjected to cluster analysis basing on the Euclidean distance and the average linkage clustering method. Statistical analysis were performed using the software Syntax2000 (Podani, 2001).

The groups identified in the dendrogram were classified, whenever possible, at association level according to the main European and Italian phytosociological literature (e.g. Mucina *et al*., 1993; Grabherr & Mucina, 1993; Valachovič, 2001; Rivas-Martínez *et al*., 2001, 2002; Chytrý, 2011; Landucci *et al*., 2013) and to the specific papers mentioned below. The syntaxonomic scheme follows Biondi & Blasi (2015) and, for some aquatic coenoses, Lastrucci *et al*. (2014). Species nomenclature follows Bartolucci *et al*. (2018) and Galasso *et al*. (2018). The specimens collected during the field survey were stored in the Herbarium Centrale Italicum (FI) and in the Herbarium of the Department of Biologia of the University of Florence.

Results and discussion

Cluster analysis

The cluster analysis allows to identify 13 groups, interpreted as 12 vegetation types (see following chapters). The clusters A-B include hydrophyte-dominated relevés; the cluster C groups hydrophyte-dominated relevés rich in marsh species, resulting in the dendrogram close to some of the clusters of helophyte-dominated relevés (D-G); the clusters H-I include hemicryptophyte/geophyte-dominated relevés; the clusters J-K include therophyte-dominated relevés, as well the cluster L, grouping the *Sporobolus schoenoides*-dominated relevés.

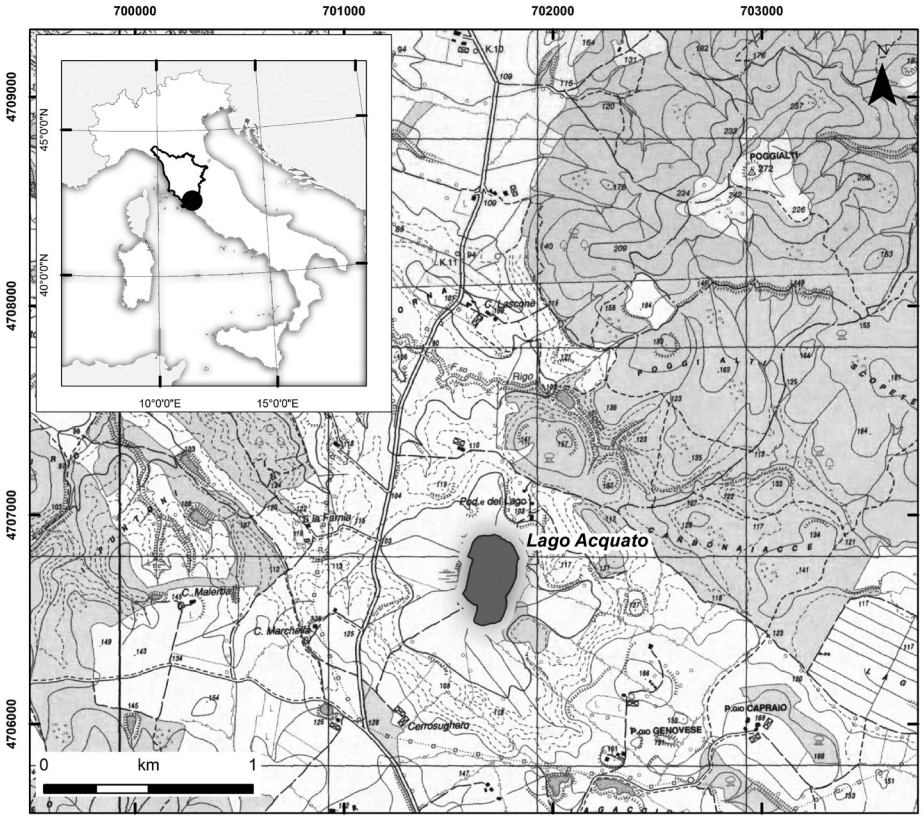

Fig. 1 - Study area.

The vegetation

Aquatic vegetation of the classes Lemnetea minoris *and* Potametea pectinati

CERATOPHYLLETUM DEMERSI Corillion 1957
(Rels. 1-4, Tab. 1; gr. A of cluster Fig. 2)

A phytocoenosis dominated by *Ceratophyllum demersum* was detected in the pond near the lake Acquato. The community can be attributed at the association *Ceratophylletum demersi* Corillion 1957, typical of water bodies with still or slowly running, eutrophic to hypertrophic waters (Sumberová, 2011a). *Ceratophyllum demersum* communities have been reported both in shallow (e.g. Sburlino *et al*., 2004; Sumberová, 2011a) and in deep waters (Buchwald, 1995; Lastrucci *et al*., 2014). In the study area the community grows in the deepest areas of the pond and tolerates strong water-level variation, as already put in evidence by other authors (Hrivnák, 2002). In Tuscany the association was reported from the southern to the north-western wetlands of the region (Lastrucci *et al*., 2006, 2014, 2016).

POTAMETUM LUCENTIS Hueck 1931
(Rels. 5-6, Tab. 1; gr. C of cluster Fig. 2)

The strong changes in the level of the Lake Acquato, the density of the helophytes and the anthropogenic disturbance factors affecting the small biotope represent negative factors for the optimal development of hydrophyte vegetation. Tomei *et al*. (1986) already underlighted the exiguity of hydrophytic flora. It is important to note, however, that all the aquatic species previously reported in literature (see also Guazzi & Tomei, 1996) were confirmed by our observations. The only aquatic vegetation type, rather diffused in the lake, is represented by *Potametum lucentis* Hueck 1931, developing on the shallow and small open areas between the helophytic vegetation. This association was reported also for the lake of La Sdriscia near Capalbio (Lastrucci *et al*., 2007). Few other hydrophytes are present in the relevés (*Ranunculus rionii* and the aquatic ecophene of *Persicaria amphibia*). The high presence of helophytes in the rel. 6 testifies the close contact of this association with the marsh vegetation.

RANUNCULETUM RIONII Hejný et Husák in Dykyjová et Květ 1978 *nom. mut. propos.*
(Rels. 7-8, Tab. 2; gr. B of cluster Fig. 2)

At the edge of the pond near the lake Acquato a belt of hydrophytic vegetation dominated by *Ranunculus rionii* was found. The study area represents the first site for in which this species was collected in Tuscany (Lastrucci *et al*., 2019). This kind of vegetation is in contact with the *Ceratophylletum demersi*, developing in the shallower waters along the pond shores. After the partial draining of the pool during the summer this kind of vegetation tends to rarify and the only vegetation type occupying the waters of the pool is constituted by the *Ceratophylletum demersi*. From the syntaxonomic point of view this coenosis can be attributed to the association *Ranunculetum rionii* Hejný et Husák in Dykyjová et Květ 1978 *nom. mut. propos.*, occurring in shallow, eutrophic and often salt-rich, warm fish-pond margins and pools at depths of 20–60 cm (Sumberová, 2011b). The association is here recorded for the first time in Tuscany and, based on the databases of Lisy (Bracco *et al*., 2007) and VegItaly (Landucci

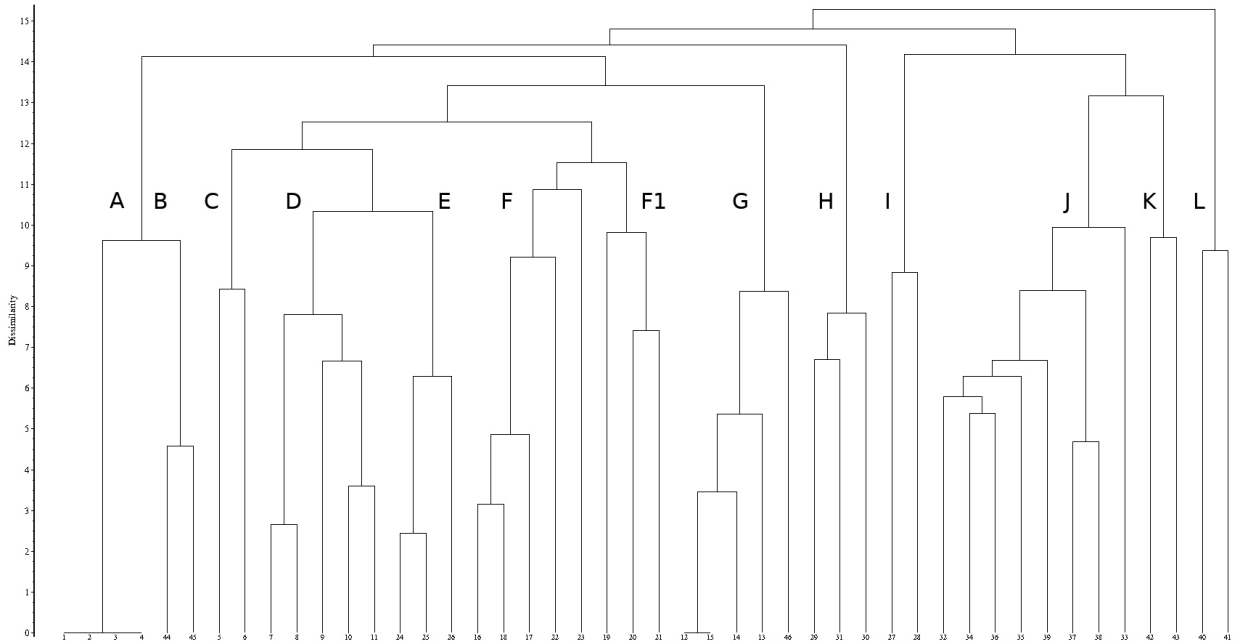

Fig. 2 - Dendrogram of the phytosociological relevés.

Tab. 1 - Vegetation of the classes *Lemnetea minoris* and *Potametea pectinati*.

Rel. number	1	2	3	4	5	6	7	8
Total cover (%)	100	100	100	100	70	100	90	100
Surface (m^2)	10	10	10	10	2	2	4	4
Rel. number in the cluster	1	2	3	4	5	6	44	45
Pleustophytic vegetation of the *Lemnetea minoris* class								
Ceratophylletum demersi								
Ceratophyllum demersum L.	5	5	5	5	.	.	1	3
Rhizophytic vegetation of the *Potametea pectinati* class								
Potametum lucentis								
Potamogeton lucens L.	.	.	.	.	4	4	.	.
Ranunculetum rionii								
Ranunculus rionii Lagger	.	.	.	.	+	.	5	4
Characteristic species of *Potamion pectinati* and upper units								
Potamogeton crispus L.	.	.	.	.	.	.	+	.
Persicaria amphibia (L.) Delarbre aquat. ecoph.	.	.	.	.	.	+	.	.
Other species								
Schoenoplectus lacustris (L.) Palla	.	.	.	.	.	2	.	.
Bolboschoenus glaucus (Lam.) S.G. Sm.	.	.	.	.	.	2	.	.
Phragmites australis (Cav.) Trin. ex Steud.	.	.	.	.	.	1	.	.
Alisma plantago-aquatica L.	.	.	.	.	+	.	.	.

Tab. 2 - Marsh vegetation of the class *Phragmito-Magnocaricetea*.

Rel. number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Total cover (%)	100	100	100	70	60	100	100	100	100	95	100	85	50	100	70	100	80	100	100	100	100
Surface (m^2)	20	10	20	20	30	10	20	20	10	20	4	4	8	10	10	10	10	10	10	10	10
Rel. number in the cluster	7	8	9	10	11	12	15	14	13	46	24	25	26	16	18	17	22	23	19	20	21
Schoenoplectetum lacustris																					
Schoenoplectus lacustris (L.) Palla	5	5	4	4	4	.	.	.	.	.	2	1	.	.	.	.	2	+	+	+	+
Phragmitetum australis																					
Phragmites australis (Cav.) Trin. ex Steud.	1	+	.	.	.	5	5	5	5	5	.	.	1	.	.	+	.	.	+	.	+
Eleocharitetum palustris																					
Eleocharis palustris (L.) Roem. & Schult. subsp. palustris	.	.	1	1	1	.	.	.	.	2	5	5	3	.	.	.	.	.	1	.	.
Bolboschoenetum glauci	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bolboschoenus glaucus (Lam.) S.G. Sm.	2	2	2	.	+	.	.	.	+	+	+	+	+	5	4	5	4	3	4	4	2
Upper units of the *Phragmito-Magnocaricetea* class																					
Alisma plantago-aquatica L.	.	.	2	1	+	.	.	+	.	2	1	+	+	.	.	r	2	+	2	2	2
Persicaria amphibia (L.) Delarbre terr. ecoph.	1	+	.	.	.	.	.	.	+	+	.	.	1	.	+	.	.	.	+	.	.
Alisma lanceolatum With.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.
Sparganium erectum L.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Glyceria fluitans (L.) R. Br.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Therophytes of *Bidentetea* and *Isoëto-Nanojuncetea* classes																					
Veronica anagalloides Guss.	.	.	1	+	+	.	.	.	.	+	.	.	.	+	1	1	.	.	2	1	+
Polypogon monspeliensis (L.) Desf.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2	+	+
Xanthium italicum Moretti	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	2	+
Bidens frondosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	+
Lythrum hyssopifolia L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.
Ranunculus sardous Crantz subsp. sardous	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+
Echinochloa crus-galli (L.) P.Beauv. subsp. crus-galli	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Perennial species of wet and disturbed habitats																					
Agrostis stolonifera L.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+
Elymus repens (L.) Gould subsp. repens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	4
Carex otrubae Podp.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.
Rumex crispus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1
Paspalum distichum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	4	.	.	.
Juncus articulatus L. subsp. articulatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Plantago major L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Rumex conglomeratus Murray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Hydrophytes																					
Ranunculus rionii Lagger	.	.	.	+	.	.	.	+	.	.	r	.	.	.	.	.	.	.	.	.	.
Potamogeton lucens L.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chara sp.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Other species																					
Solanum dulcamara L.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Abutilon theophrasti Medik.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Salix alba L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.

et al., 2012; Venanzoni *et al*., 2012) for the national territory.

Marsh vegetation of the class Phragmito-Magnocaricetea

SCHOENOPLECTETUM LACUSTRIS Chouard 1924
(Rels. 1-5, Tab. 2; gr. D of cluster Fig. 2)

In the central/western part of the Lake Acquato dense stands of *Schoenoplectus lacustris* have been detected. This kind of vegetation can be attributed to *Schoenoplectetum lacustris* Chouard 1924. In the study site the association develops on the long-submerged swamp areas, confirming the trend observed also by Lastrucci *et al*. (2007) for the Lagaccioli ponds; this can be related to the high photosynthetic efficiency of *S. lacustris* during the submersion time (Poldini, 1989). As the water depth decreases, the association tends to form a mosaic with other *Phragmition* (*Phragmitetum australis*) or *Eleocharito-Sagittarion* coenoses.

PHRAGMITETUM AUSTRALIS Savič 1926
(Rels. 6-10, Tab. 2; gr. G of cluster Fig. 2)

This association is the more widespread vegetation type of the Lake Acquato. *Phragmitetum australis* develops with dense stands often monospecific or rather poor in species, confirming a general characteristic of this kind of phytocoenosis (Venanzoni & Gigante, 2000; Lastrucci *et al*., 2017b).

The reed-bed develops from the shallow waters up to the peripheral areas of the small biotope, fastly emerging at the beginning of the summer. In the late-summer the more external stands of the reed-bed in contact with the surrounding cultivated areas were subject to extensive mowing.

ELEOCHARITETUM PALUSTRIS Savič 1926
(Rels. 11-13, Tab. 2; gr. E of cluster Fig. 2)

Eleocharis palustris subsp. *palustris* tends to form pioneering communities generally preceding the coenoses dominated by large-size helophytes (Biondi *et al*., 1997). In the study area this community develops at the edge of the *Phragmition* coenoses, forming small stands poor in species, according to the features of the *Eleocharitetum palustris* Savič 1926 (Venanzoni & Gigante, 2000). The association was already reported for other wetlands near Capalbio (Lastrucci *et al*., 2007).

BOLBOSCHOENETUM GLAUCI Grechushkina, Sorokin & Golub 2011
(Rels. 14-21, Tab. 2; gr. F and F1 of cluster Fig. 2)

In the study area the *Bolboschoenus glaucus*-dominated vegetation forms a belt on muddy soils covered by shallow waters and progressively drying during the summer, in contact on one side with the reed-bed and on the other with the hygrophilous therophytic vegetation and the segetal communities. This kind of vegetation represents a transition between the perennial high-tall helophytic coenoses of the *Phragmition* alliance and the coenoses of the disturbed and drying sites.

Hroudová *et al*. (2007, 2009) reported that *B. glaucus* represents the species with the southernmost distribution among the European ones of the genus *Bolboschoenus*. From the phytosociological point of view, data on this kind of vegetation are scarce also because this species does not occur in the Central-European plant communities. A paucispecific *B. glaucus*-dominated community including also halophytic species such as *Aeluropus littoralis* (Gouan) Parl. or *Salicornia prostrata* Pall. was described for the Russian coast of the Azof Sea with the name *Bolboschoenetum glauci* Grechushkina, Sorokin & Golub 2011 (Grechushkina *et al*., 2011). Nowak *et al*. (2013, 2014), however, included in the association also communities with a higher number of species, attributing to this syntaxon a rather high ecological amplitude and including it in the *Eleocharito-Sagittarion* alliance. This interpretation fits with the syntaxonomic interpretation of some Italian *B. glaucus* coenoses by Landucci *et al*. (2013) and Lastrucci *et al*. (2014).

Our relevés were thus referred to the association *Bolboschoentum glauci*, included in the *Eleocharito-Sagittarion* alliance, typical of the periodically flooded habitats, often subjected to strong water level fluctuation, occupying an intermediate position between the hydrophytic communities and the coenoses of *Phragmitetalia* or playing a role of secondary replacement communities as a consequence of natural vegetation disturbance (see Otahelová, 2001). The community of the Lake Acquato shows the presence of several species of the *Phragmito-Magnocaricetea* class such as *Phragmites australis*, *Schoenoplectus lacustris*, *Alisma plantago-aquatica*, *A. lanceolatum* and *Eleocharis palustris* subsp. *palustris*. In addition in the lower layer of the community it can be noted a pool of therophytes such as *Veronica anagalloides*, *Xanthium italicum*, *Lythrum hyssopifolia*, *Ranunculus sardous* or *Polypogon monspeliensis*. Another floristic component is represented by some perennial hygro-nitrophilous pioneer species of disturbed habitats such as *Paspalum distichum* or *Elymus repens* subsp. *repens*, sometimes with high cover values. The presence of perennial species of *Agrostietea stoloniferae* class is particularly significant in the more stable areas, less long-flooded (gr. F1 of the dendrogram) indicating the transition towards the wet meadow coenoses.

Therophitic hygro-nitrophilous vegetation of the class Bidentetea tripartitae

XANTHIO ITALICI-PERSICARIETUM MACULOSAE O. Bolos l957 *nom. mut. propos.* var. with *Abutilon theophrasti*
(Tab. 3; gr. K of cluster Fig. 2)

Tab. 3 - *Xanthio italici-Persicarietum maculosae* variant with *Abutilon theophrasti*.

Rel. number	1	2
Total cover (%)	100	100
Surface (m^2)	4	4
Rel. number in the cluster	42	43
Charact. of *Xanthio italici-Persicarietum maculosae*		
Xanthium italicum Moretti	5	2
Persicaria maculosa (L.) Gray	+	.
Variant with *Abutilon theophrasti*		
Abutilon theophrasti Medik.	1	4
Charact. of *Bidentetea tripartitae* units		
Bidens frondosa L.	1	+
Echinochloa crus-galli (L.) P.Beauv. subsp. crus-galli	+	+
Atriplex prostrata Boucher ex DC.	+	1
Symphyotrichum squamatum (Spreng.) G.L. Nesom	1	1
Other species		
Veronica anagalloides Guss.	1	1
Plantago major L.	1	+
Galega officinalis L.	+	+
Sporobolus schoenoides (L.) P.M.Peterson	1	.
Trifolium fragiferum L. subsp. fragiferum	.	1
Convolvolus arvensis L.	.	+
Alisma plantago-aquatica L.	+	.
Elymus repens (L.) Gould subsp. repens	+	.
Agrostis stolonifera L.	+	.
Lotus tenuis Waldst. & Kit. ex Willd.	.	+
Polypogon monspeliensis (L.) Desf.	.	+
Alisma lanceolatum With.	.	+

Between the helophytic vegetation and the cultivated fields, on the humid soils drying in summer, a vegetation dominated by hygro-nitrophilous terophytes was found. This kind of coenosis replaces or forms a mosaic with the small therophytic coenoses of the *Isoëto-Nanojuncetea* class. For the syntaxonomic attribution we refer to the association *Xanthio italici-Persicarietum maculosae*, growing on nutrient-rich soils in late summer, replacing the ruderal communities of the *Stellarietea mediae* class on inundated soils (Amor *et al*., 1993). The association was reported also for the Lagaccioli ponds near Capalbio (Lastrucci *et al*., 2007) and for the Valdichiana valley (Lastrucci *et al*., 2010b). As for the Valdichiana valley in the samples near the lake Acquato *Abutilon theophrasti*, an alien segetal weed (Covarelli, 2002) can be detected even becoming dominant. These stands can be interpreted as a variant indicating the contact with the weed ruderal nitrophilous and sub-nitrophilous vegetation of the *Stellarietea* class.

Small annual hygrophytic vegetation of the class Isoëto-Nanojuncetea

VERONICO ANAGALLOIDIS-LYTHRETUM HYSSOPIFOLIAE Wagner ex Holzner 1973 var. with *Polypogon monspeliensis* and *Xanthium italicum*

(Rels. 1-8, Tab.4; gr. J of cluster Fig. 2)

In the belt between the coenoses of the *Phragmito-Magnocaricetea* class and the cultivated fields around the lake, an early community developing on wet soils quickly drying during the summer was observed. It is characterized by hygrophilous therophytes of muddy (*Veronica anagalloides*, *Lythrum hyssopifolia*, *Ranunculus sardous*), or sandy soils (*Polypogon monspeliensis* and *Xanthium italicum*) with some small helophytes such as *Alisma plantago-aquatica* or *A. lanceolatum*. From the ecological point of view many affinities with the association *Veronico anagalloidis-Lythretum hyssopifoliae* Wagner ex Holzner 1973 were found; this association develops in more or less humid soils, often characterized by a strong disturbance degree caused by the agricultural practices, sometimes in low salinity conditions; the association shows different features related to the substrate conditions, reverberating on different floristic composition according to the humidity gradient (Traxler, 1993; Šumberová, 2011c). In the Acquato lake a thermophilous variant with sandy soil species as *Polypogon monspeliensis* and *Xanthium italicum* was identified. This kind of vegetation is here recorded for the first time in Tuscany and, based on the databases of Lisy (Bracco *et al*., 2007) and VegItaly (Landucci *et al*., 2012; Venanzoni *et al*., 2012), also for Italy.

SPOROBOLUS SCHOENOIDES community

(Rels. 9-10, Tab. 4; gr. L of cluster Fig. 2)

In the sandy soils inundated until the late spring, near the cultivated areas a community dominated by *Sporobolus schoenoides* was found. This species is characteristic of the *Heleochloetum schoenoidis* (Soó 1933) Topa 1939, a markedly halophilous association (Hejný & Husák, 1978). From an ecological point of view, the community of the Lake Acquato shows more affinity with the association *Crypsido schoenoidis-Juncetum bufonii* described for the Musone river plain (Marche) by Biondi *et al*. (2002) and attributed to the *Nanocyperion* alliance. Compared with the original association, at the Lake Acquato it can be noted the strong dominance of *S. schoenoides*, while *Juncus bufonius* occurs with a very low cover value in only one relevé.

Wet meadow vegetation of the class Agrostietea stoloniferae

CARICI OTRUBAE-JUNCETUM INFLEXI Minissale & Spampinato 1996

(Rels. 1-2 Tab. 5; gr. I of cluster Fig. 2)

On the south-eastern shore of the lake, on damp but not submerged soil between the reed bed and the belt of hygrophilous vegetation dominated by therophytes, a community dominated by *Juncus inflexus* subsp. *inflexus* was found. This community includes several species of the *Agrostietea stoloniferae* class. Due to its floristic connotation it was referred to the associa-

Tab. 4 - Vegetation of the class *Isoëto-Nanojuncetea*.

Rel. number	1	2	3	4	5	6	7	8	9	10
Total cover (%)	100	100	100	70	90	90	100	70	80	100
Surface (m^2)	8	4	4	4	10	6	6	4	3	4
Rel. number in the cluster	32	34	36	35	39	37	38	33	40	41
Veronico anagalloidis-Lythretum hyssopifoliae										
Veronica anagalloides Guss.	4	5	5	4	4	4	4	2	r	r
Ranunculus sardous Crantz subsp. sardous	1	+	+	+	2	1	+	+	.	.
Lythrum hyssopifolia L.	+	.	.	+	.	+	.	4	.	.
Diff. of the variant										
Polypogon monspeliensis (L.) Desf.	1	+	+	+	+	1	1	+	.	.
Xanthium italicum Moretti	2	1	1	+	1	+	1	+	.	.
Sporobolus schoenoides community										
Sporobolus schoenoides (L.) P.M.Peterson	.	.	.	1	.	+	.	.	4	5
Charact. of *Isoeto-Nanojuncetea* units										
Mentha pulegium L. subsp. pulegium	.	+	.	.	.	+	.	.	2	1
Juncus bufonius L.	.	.	.	.	.	.	.	.	.	r
Cyperus fuscus L.	.	.	.	.	.	.	.	.	r	.
Other species										
Alisma plantago-aquatica L.	+	.	+	+	+	2	2	+	.	.
Alisma lanceolatum With.	+	+	1	+	+	.	.	1	.	+
Phragmites australis (Cav.) Trin. ex Steud.	.	.	+	.	+	.	.	.	1	.
Bolboschoenus glaucus (Lam.) S.G. Sm.	+	.	.	.	1	.	.	.	+	.
Sparganium erectum L.	+	.	+	+	.	.	.	.	.	.
Schoenoplectus lacustris (L.) Palla	+	.	.	+	.	.	.	+	.	.
Symphyotrichum squamatum (Spreng.) G.L. Nesom	.	.	.	.	.	1	1	.	.	.
Rumex conglomeratus Murray	.	.	+	.	1	.	.	.	.	.
Rumex crispus L.	+	+	.	.	.	.	.	.	.	.
Kickxia spuria (L.) Dumort. subsp. spuria	.	r	.	.	.	.	.	.	.	1
Lotus tenuis Waldst. & Kit. ex Willd.	.	.	.	.	.	.	.	.	.	2
Portulaca trituberculata Danin, Domina & Raimondo	.	.	.	.	.	.	.	.	1	.
Persicaria lapathifolia (L.) Delarbre subsp. lapathifolia	.	.	.	.	.	.	.	.	.	1
Polygonum aviculare L. subsp. aviculare	.	.	.	.	.	.	.	.	.	+
Persicaria maculosa (L.) Gray	.	.	.	.	.	+	.	.	.	.
Persicaria amphibia (L.) Delarbre	.	.	.	+	.	.	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	.	+	.
Lepidium coronopus (L.) Al-Shehbaz	.	.	.	.	.	.	+	.	.	.
Convolvulus althaeoides L.	.	+	.	.	.	.	.	.	.	.
Bidens tripartita L.	.	.	.	.	.	.	.	.	.	+

tion *Carici otrubae-Juncetum inflexi* described for the Gurrida Lake in North-Eastern Sicily by Minissale & Spampinato (1986). The association has a subnitrophilous characters and, even developing on periodically flooded soils, shows a marked tolerance to periods of prolonged xericity (Minissale & Spampinato, 1986).

CAREX HIRTA and *CAREX OTRUBAE* community (Rels. 3-5, Tab. 5; gr. H of cluster Fig. 2)

In the southern part of the lake, at the edge of a hygrophilous grove of *Salix alba*, a dense vegetation with *Carex otrubae* and *Carex hirta* was found. This community grows on fresh, partially shaded and not submerged soils. From a phytosociologic point of view, *Carex hirta* is considered a species with a high ecological amplitude (Tomaselli & Bernardo, 2006; Lastrucci *et al*., 2010a). This community, showing a mixture of palustrine elements and wet meadow species, can be configured as a community of transition towards the coenoses of the most stable and not flooded habitats.

Habitats of conservation interest

Two habitats of conservation value were identified through the phytosociological approach (see Biondi *et al*., 2009, 2012; Gigante *et al*., 2016). The first one corresponds to the habitat 3150 (Natural euthrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation) represented by the associations *Ceratophylletum demersi* and *Potamentum lucentis*, belonging respectively to the class *Lemnetea minoris* and *Potametea pectinati*. The habitat attribution of the *Ranunculetum rionii*, is instead rather critical. Even if the *Ranunculion aquatilis* alliance includes communities of both stagnant and slowly running waters, according to the Italian Interpretation Manual of the 92/43/CEE Directive Habitats (Biondi *et al*., 2009) it configures formally the habitat 3260 (Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation), although an overlap often occurs between the indicator

Tab. 5 - Vegetation of the class *Agrostietea stoloniferae*.

Rel. number	1	2	3	4	5
Total cover (%)	100	100	80	100	100
Surface (m^2)	10	4	8	10	10
Rel. number in the cluster	27	28	29	31	30
Carici otrubae-Juncetum inflexi					
Carex otrubae Podp.	1	1	1	1	4
Juncus inflexus L. subsp. inflexus	4	3	.	.	.
Carex hirta and *Carex otrubae* community					
Carex hirta L.	.	.	4	5	3
Characteristic species of upper units					
Agrostis stolonifera L.	1	2	.	+	+
Rumex conglomeratus Murray	1	+	.	.	+
Potentilla reptans L.	.	+	+	.	+
Juncus articulatus L. subsp. articulatus	+	2	.	.	.
Juncus effusus L.subsp. effusus	.	1	.	.	.
Lotus tenuis Waldst. & Kit. ex Willd.	+	.	.	.	.
Other species					
Veronica anagalloides Guss.	2	1	+	.	+
Phragmites australis (Cav.) Trin. ex Steud.	+	1	+	+	.
Xanthium italicum Moretti	2	2	.	.	.
Polypogon monspeliensis (L.) Desf.	+	2	.	.	.
Alisma plantago-aquatica L.	.	.	1	.	1
Salix alba L.	.	.	+	1	.
Schoenoplectus lacustris (L.) Palla	+	+	.	.	.
Solanum dulcamara L.	.	.	+	.	+
Lycopus europaeus L.	.	+	.	r	.
Bidens frondosa L.	.	.	.	+	r
Bolboschoenus glaucus (Lam.) S.G. Sm.	.	.	.	+	.
Juncus bufonius L.	+	.	.	.	.
Lolium multiflorum Lam.	+	.	.	.	.
Lolium perenne L.	+	.	.	.	.
Persicaria amphibia (L.) Delarbre	.	.	+	.	.
Plantago major L.	+	.	.	.	.
Symphyotrichum squamatum (Spreng.) G.L. Nesom	+	.	.	.	.
Cyperus fuscus L.	.	.	.	+	.
Ranunculus sardous Crantz subsp. sardous	+	.	.	.	.
Lythrum hyssopifolia L.	+	.	.	.	.
Callitriche sp.	.	.	.	r	.

species of the 3150 and 3260. The presence of this latter habitat is however related to river ecosystems (see Bracco, 2016) and its occurrence in a biotope like the lake Acquato, missing of any tributaries, is probably not appropriate. Due the annual life cycle of *Ranunculus rionii* and its optimum ecological requirements (ephemeral aquatic habitats such as wheel ruts, puddles or small pools, see Englmaier, 2016), the *Ranunculetum rionii* should instead configure an aspect related to the first evolution stage of the habitat 3130, which constitutes the second habitat of conservation value detected in the study area. The habitat 3130 (Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*) is represented in the study area by the *Veronico anagalloidis-Lythretum hyssopifoliae* Wagner ex Holzner 1973 and by the *Sporobolus schoenoides* community.

Syntaxonomic scheme

LEMNETEA MINORIS O. Bolòs & Masclans 1955
UTRICULARIETALIA MINORIS Den Hartog & Segal 1964
Ceratophyllion demersi Den Hartog & Segal ex Passarge 1996
Ceratophylletum demersi Corillion 1957

POTAMETEA PECTINATI Klika in Klika & V. Novák 1941
POTAMETALIA PECTINATI Koch 1926
Potamion pectinati (W. Koch 1926) Libbert 1931
Potametum lucentis Hueck 1931
Ranunculion aquatilis Passarge 1964
Ranunculetum rionii Hejný et Husák in Dykyjová et Květ 1978 *nom. mut. propos.*

BIDENTETEA TRIPARTITAE Tüxen, Lohmeyer & Preising ex Von Rochow 1951
BIDENTETALIA TRIPARTITAE Br.-Bl. & Tüxen ex Klika in Klika & Hadac 1944
Bidention tripartitae Nordhagen 1940
Xanthio italici-Persicarietum maculosae O. Bolos l957 *nom. mut. propos.* var. with *Abutilon theophrasti*

ISOËTO-NANOJUNCETEA Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946
NANOCYPERETALIA FLAVESCENTIS Klika 1935
Verbenion supinae Slavnić 1951
Veronico anagalloidis-Lythretum hyssopifoliae Wagner ex Holzner 1973 var. with *Polypogon monspeliensis* and *Xanthium italicum*
Nanocyperion flavescentis Koch 1926
Sporobolus schoenoides community

PHRAGMITO-MAGNOCARICETEA Klika in Klika et Novák 1941
PHRAGMITETALIA Koch 1926
Phragmition communis Koch 1926
Schoenoplectetum lacustris Chouard 1924
Phragmitetum australis Savič 1926
OENANTHETALIA AQUATICAE Hejný ex Bálatová-Tuláčková, Mucina, Ellmauer et Wallnöfer in Grabherr et Mucina 1993
Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964
Eleocharitetum palustris Savič 1926
Bolboschoenetum glauci Grechushkina, Sorokin & Golub 2011

AGROSTIETEA STOLONIFERAE Oberdorfer 1983
POTENTILLO ANSERINAE-POLYGONETALIA AVICULARIS Tüxen 1947
Mentho longifoliae-Juncion inflexi Müller & Görs ex de Foucault 2008
Carici otrubae-Juncetum inflexi Minissale & Spampinato 1996
Carex hirta and *Carex otrubae* community

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