ISSN 2704-6192 (Online) ISSN 2280-1855 (Print)

PLANT SOCIOLOGY

formerly FITOSOCIOLOGIA

Volume 56 (2) - December 2019

RIVISTA SEMESTRALE - POSTE ITALIANE S.P.A. - SPED. ABB. POST. - D.L. 353/2003 - (CONV. IN L. 27/02/2004 N. 46) ART. 1, COMMA 2, DCB ANCONA TASSA RISCOSSA-TAXE PERÇUE-CMPP AN
EDITO DALLA SOCIETA' ITALIANA DI SCIENZA DELLA VEGETAZIONE ONLUS - PAVIA - DIRETTORE RESPONSABILE. D. GIGANTE - VOLUME 2 - II° SEMESTRE 2019

Journal of the Italian Society for Vegetation Science

Plant Sociology, Vol. 56, No. 2, December 2019, pp. 53-68
DOI 10.7338/pls2019562/04

PLANT SOCIOLOGY
©Italian Society for Vegetation Science

Contribution to the knowledge of Mediterranean wetland biodiversity: Plant communities of the Aquila Lake (Calabria, Southern Italy)

G. Spampinato[1], S. Sciandrello[2], G. Giusso del Galdo[2], M. Puglisi[2], V. Tomaselli[3], S. Cannavò[1], C.M. Musarella[1]
[1]Department of Agraria, "Mediterranea" University of Reggio Calabria, Loc. Feo di Vito snc, I-89122 Reggio Calabria, Italy.
[2]Department of Biological, Geological and Environmental Sciences, University of Catania, Italy.
[3]National Research Council - Institute of Biosciences and BioResources (CNR-IBBR), via G. Amendola 165/A, 70126 Bari, Italy.

Giovanni Spampinato https://orcid.org/0000-0002-7700-841X, Saverio Sciandrello https://orcid.org/0000-0003-1132-5698, Gianpietro Giusso del Galdo https://orcid.org/0000-0003-4719-3711, Marta Puglisi https://orcid.org/0000-0002-4810-3370, Valeria Tomaselli https://orcid.org/0000-0001-9121-9558, Carmelo Maria Musarella https://orcid.org/0000-0002-0120-190X

Abstract
As part of researches undertaken on the aquatic and marsh vegetation of southern Italy, a study on the Aquila Lake, a small lake basin in southern Calabria near Rosarno (RC), is here presented. Overall, 86 phytosociological relevés were carried out. The phytosociological study allowed the identification of several aquatic and marsh phytocoenoses, many of which not yet known for the region. They are referable to the following 8 classes: *Lemnetea minoris* R. Tx. ex O. Bolòs & Masclans 1955, *Potametea pectinati* R.Tx. & Preising 1942, *Phragmito australis-Magnocaricetea elatae* Klika in Klika & Novák 1941, *Agrostietea stoloniferae* Oberdorfer 1983, *Galio aparines-Urticetea dioicae* Passarge ex Kopecký 1969, *Molinio-Arrhenatheretea* Tüxen 1937, *Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantó ex Rivas-Martínez *et al*. 2001, *Querco roboris-Fagetea sylvaticae* Br.-Bl. & Vlieger in Vlieger 1937. A peculiar marsh vegetation is the *Cladietum marisci* Allorge 1922 ex Zobrist 1935 (habitat of Community interest, according to the EEC directive 43/92 - 7210 *Calcareous ferns with *Cladium mariscus* and species of the *Caricion davallianae*"). In the Aquila Lake, some rare aquatic plant communities highlight the importance of this biotope for biodiversity conservation. In particular, we found the pleustophytic associations *Lemno-Spirodeletum polyrhizae* Koch 1954, *Lemno minoris-Hydrocharitetum morsus-ranae* Passarge 1978 and the aquatic rooted vegetation of *Nymphaeetum albae* Vollm. 1947. Despite the heavy pressures on this area, the biotope harbours a well-differentiated and structured aquatic and marsh vegetation that allows the presence of a rich bird life, both sedentary and migratory. The area, privately owned, is not protected; hunting and fishing are practiced and water is pumped for irrigation with negative consequences on the integrity of the entire aquatic ecosystem. Because of its naturalistic peculiarities and its remarkable biodiversity, this biotope certainly deserves more attention and should be proposed as a protected area.

Key words: Cluster analysis, Italy, phytosociology, Reggio Calabria, wetland vegetation.

Introduction

Wetlands are special places for biodiversity conservation. They host very peculiar plant and animal communities living only in these environments and a remarkable habitats richness, diversified even by minimal variations in chemical-physical parameters, water levels or soil composition (Dudgeon *et al*., 2006). Due to the importance that wetlands assume for biodiversity conservation, they are object of several national and European projects and initiatives, such as MedWet (2018) and WetVegEurope (2018).

Wetlands are in sharp contraction through the world, mainly due to climate change and the expansion of agricultural and urban areas. Water and marsh habitats are among the most threatened of extinction.

As testified by several authors (De Leone, 1783; Galanti, 1792), the coastal strip of Calabria was occupied by extensive marshy areas until the beginning of the 19th century, and subsequently subjected to intense reclamation activities to combat malaria and obtain land for agricultural activities (Petrucci, 1997). A diacronic analysis of historical maps and flora inventories available for the Calabria region has highlighted the changes that have affected the coastal wetlands of Calabria in the last two centuries and the consequences on the reduction of wetlands and the impact of the flora, highlighting a contingent of species in rarefaction, or already disappeared (Spampinato *et al*., 2007).

Wetland flora and vegetation in southern Italy have often been a subject of scientific interest and several studies have been carried out to increase the knowledge of these particular ecosystems. We can find many scientific contributions especially in Sicily (Minissale & Spampinato, 1987; Brullo & Spampinato, 1990; Brullo *et al*., 1994; Brullo & Sciandrello, 2006; Scian-

Corresponding author: Carmelo Maria Musarella. *Department of Agraria, "Mediterranea" University of Reggio Calabria, Loc. Feo di Vito snc, I-89122 Reggio Calabria, Italy; e-mail: carmelo.musarella@unirc.it*

drello *et al*., 2014), but also in Apulia (Beccarisi *et al*., 2006, 2007; Tomaselli *et al*., 2011; Sciandrello & Tomaselli 2014; Tomaselli & Sciandrello 2017; Veronico *et al*., 2017) and Campania (La Valva & Astolfi, 1988; Strumia, 2004). In Calabria, wetlands have been studied mainly in protected areas (Bernardo *et al*., 2012; Brullo & Spampinato, 1997; Brullo & Spampinato, 1999; Brullo *et al*., 2001; Maiorca *et al*., 2002, 2007; Cameriere *et al*., 2008).

In previous contributions, we highlighted the importance of Aquila Lake for the conservation of the flora and marsh habitats (Cannavò *et al*., 2008). In fact, many anthropic sources of disturbance threaten the equilibrium of the lake.

In this paper, we present the results of a phytosociological survey of the lake vegetation, based on numerical analyses. The aim of this work is to improve knowledge on a valuable wet ecosystem in order to emphasize its peculiarity and conservation value and contribute preventing its realistic risk of loss.

Materials and Methods

Study area

The Aquila Lake is one of the few natural lakes in the Calabria Region, the only one in the Province of Reggio Calabria. It is located on the Tyrrhenian side of Calabria, at an altitude of about 33 m a.s.l.; it has a perimeter of about 1.3 km and an area of 4.5 km^2 (Fig. 1). Some small tributaries with constant flow and small springs feed it. The lake has an emissary (Fosso dell'Aquila) that joins the Mesima River. The central area of the lake, about 4 m deep, is not very extensive compared to the rest of the lake, generally characterized by depths between 1 and 2 m. The surrounding hills, characterized by quaternary sedimentary formations (Pleistocene and neogenic), are 80-90 m high.

Climatic data from the Rosarno thermo-pluviometric station, the closest one to the lake, records 17.0°C as the mean annual temperature and 917 mm as the mean annual rainfall in the period 1970-2000.

According to the bioclimatic classification of Rivas-Martínez (1996-2009) the area belongs to the "Mediterranean Pluviseasonal-Oceanic" Macrobioclimate with low mesomediterranean termotype and subhumid ombrotype (Fig. 2).

The lake is what remains of an extensive and articulated marsh system existing until the early 20th century, almost completely disappeared to date, due to land reclamation activities (Spampinato *et al*., 2007). The land around the lake is intensely cultivated with various types of crops, mainly woody and irrigated, such as orchards (e.g. citrus fruits).

The Waters Thematic Service of the Provincial Department ARPACAL of Reggio Calabria (Italy) carried out chemical and physical analyses of water (Tab. 1). They show a neutral pH, on average 7.65 (spring) ÷ 7.50 (summer), with values closer to the neutrality at the centre of the lake (7.20-7.50), tending slightly to alkaline near the outlets of the small tributaries (7.50-7.90). The dissolved oxygen has a seasonal trend,

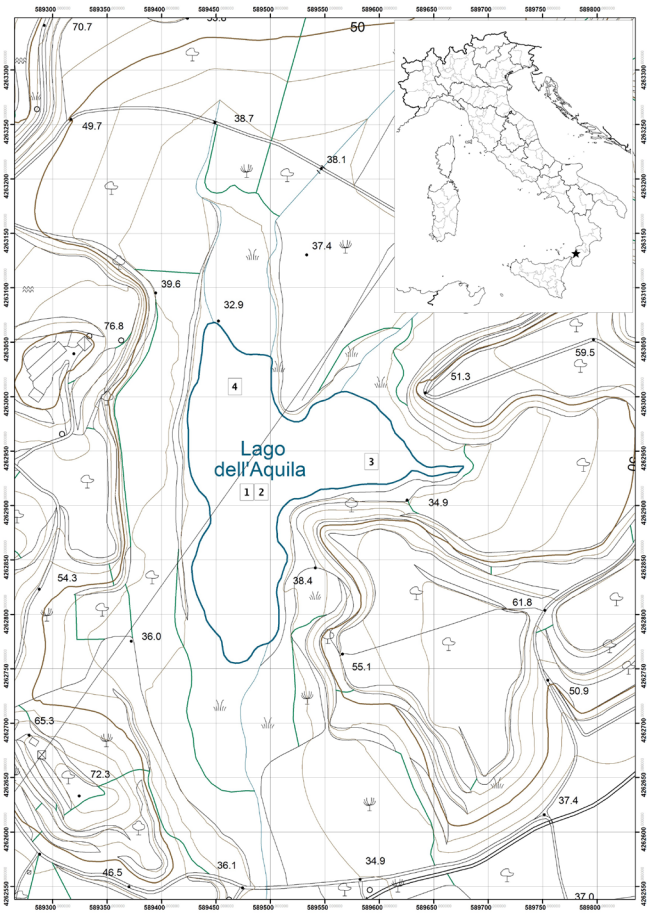

Fig. 1 - Study area. The numbers in the squares indicate the location of the sampling points for chemical-physical analysis of water.

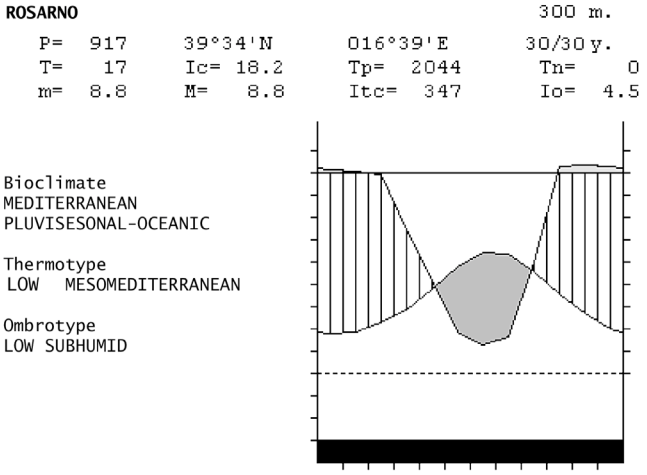

Fig. 2 - Bioclimatic diagram and diagnosis of the Rosarno (RC) thermopluviometric station.

Tab. 1 - Chemical and physical analysis of water in the sampled stations.

Sampling station	**1**		**2**		**3**		**4**	
Location	**Center of the lake**		**Center of the lake**		**East side inlet**		**North side inlet**	
Date	**Apr. 30**	**Sep. 11**	**Apr. 30**	**Sep. 11**	**Apr. 30**	**Sep. 11**	**Apr. 30**	**Sep. 11**
Depth (m)	**2**	**2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
pH	7.5	7.2	7.4	7.5	7.8	7.6	7.9	7.7
Conductivity at 20°C (µS/cm)	924	1022	922	989	885	964	887	917
Dissolved Oxygen (%)	50	< 0.5	75	3	110	4	115	6
BOD_5 (come O_2) (mg/l)	< 5	47	< 5	8	< 5	9	< 5	8
COD (come O_2) (mg/l)	50	158	45	54	55	49	35	59
Sulfates (as SO_4) (mg/l)	227	138	226	194	225	193	230	196
Cloridre (mg/l)	76	97	76	102	75	95	75	92
Sodium (mg/l)	66	83	66	80	65	80	66	77
Potassium (mg/l)	4	17	4	12	4	12	3	10
Calcium (mg/l)	97	101	97	91	90	91	88	86
Manganese (mg/l)	0.11	1.072	0.11	703	0.05	754	0.05	352
Total nitrogen (mg/l)	1	6150	0.5	1670	0.5	1590	0.5	1302
Total phosphorus (mg/l)	< 0.5	425	< 0.5	59	< 0.5	53	< 0.5	47
Fixed residue (mg/l)	600	660	600	660	575	645	580	650

with under-saturation values (7-50%) in depth, until it reaches anoxia in the summer period and values higher than the saturation on the surface in the spring period, in correspondence with the maximum photosynthetic activity of the hydrophytes. Conductivity has considerable differences in the various sample points: higher values in the centre (922-924 µS/cm) probably due to the effects of greater evaporation, while lower (885-887 µS/cm) in other parts, due to dilution of the waters by the tributaries. This trend is maintained even in the summer period with values higher than the spring period and between 917÷1022 µS/cm.

In addition, manganese has a relevant seasonal trend: in the spring, concentrations in the central area of the lake reach maximum values of 110 µg/l; in the summer period, they reach maximum values of 1072 µg/l in the deep sample. It is well known that manganese is, as a trace element, in the chlorophyll of the hydrophytes and its increase appears particularly significant precisely in conjunction with their summer decomposition. Overall, the waters are meso-eutrophic, rich in calcium sulfate in the spring and calcium bicarbonate in the summer. Similarly to many Mediterranean lakes, the Aquila Lake is a warm monomictic type, with a thermal stratification and a single period of full circulation at the end of winter, followed by a progressive stratification with maximum gradient in summer (Lewis, 1983).

Data collection and analysis

The vegetation study is based exclusively on original data and follows the plant sociological method of Braun-Blanquet (1964). According to innovative concepts specified by Biondi (2011) and Pott (2011), much more importance has been given to the minimum surface of the relevés in the vegetation survey, to avoid detecting ecotones and mosaics, frequent in these vegetation types. We consider the phytosociological approach, as a useful tool for the management of natural resources, in accordance with several authors (Brullo *et al*., 1999; Cano *et al*., 2017; Mendes *et al*., 2015; Piñar Fuentes *et al*., 2017; Pott, 2011; Quinto-Canas *et al*., 2018a, 2018b; Spampinato *et al*., 2018; Vila-Viçosa *et al*., 2015). The fieldwork was carried out during the period 2014-2018. Overall, 86 relevés have been performed.

Nomenclature of native vascular species follows Bartolucci *et al*. (2018), while the alien taxa are reported in accordance with Galasso *et al*. (2018).

Considering the relatively scarce internal heterogeneity of wet meadows, megaphorbes vegetation, shrubby communities, riparian and mesophylous woods, they have been separated without applying statistic analyses, mostly based on physiognomy and dominant species. Due to the high diversity of aquatic and marsh vegetation, a separate hierarchical Cluster Analysis of the relevés of these two macrotypes only has been performed (Linkage: Ward's method; Distance measure: Euclidean) using PC-ORD 6 software. To this purpose, the original Braun-Blanquet scale was transformed into the ordinal scale according to Van der Maarel (1979). The subsequent arrangement in tables allowed the identification of the plant communities, that were then framed according to the phytosociological syntaxonomic system. The nomenclature of the higher rank syntaxa (Classes, Orders and Alliances) is in accordance with the Prodrome of Italian Vegetation (Biondi & Blasi, 2015).

Results and discussion

The dendrogram deriving from the cluster analysis of the relevés of aquatic vegetation allowed the identification of five plant communities belonging to *Lemnetea minoris* and *Potametea pectinati* classes (Fig. 3). The cluster analysis of the marsh vegetation (Fig. 4) points

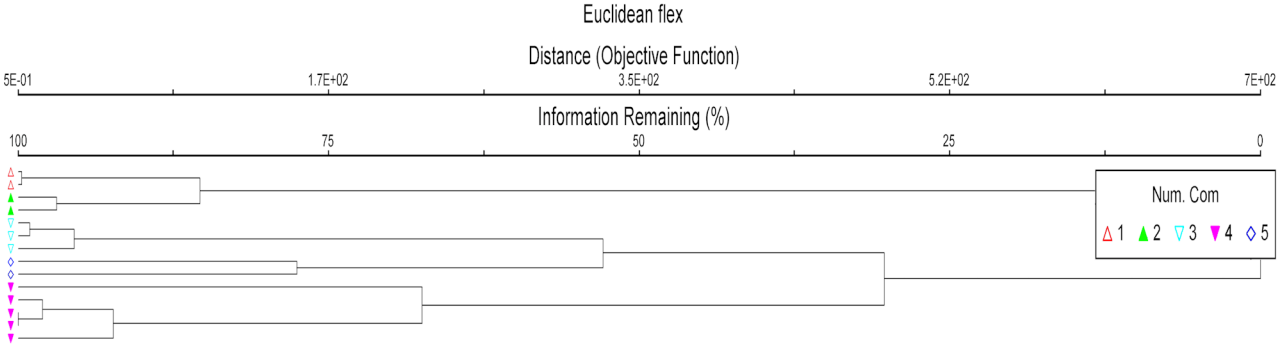

Fig. 3 - Dendrogram rising from the cluster analysis of the relevés of aquatic vegetation. The following groups are highlighted: 1 - *Lemno minoris-Spirodeletum polyrhizae*; 2 - *Lemnetum minoris*; 3 *Lemno minoris-Hydrocharitetum morsus-ranae*; 4 - *Nymphaeetum albae*; 5 - *Ceratophylletum demersi*.

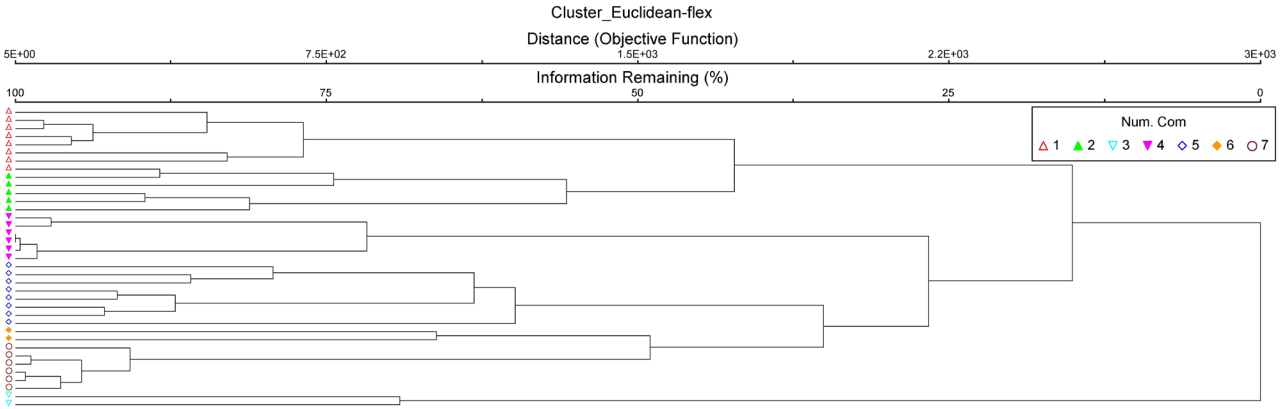

Fig. 4 - Dendrogram rising from the cluster analysis of the relevés of marsh vegetation. The following groups are highlighted: 1 - *Caricetum acutiformis*; 2 - *Caricetum ripariae*; 3 - *Cypero -Caricetum cuprinae*; 4 - *Cladietum marisci*; 5 - *Polygono salicifolii-Phragmitetum australis*; 6 - *Typhetum latifoliae*; 7 - *Schoenoplectetum lacustris*.

out seven groups of relevés that can be referred to well defined plant communities belonging to *Phragmitetalia australis* and *Magnocaricetalia elatae*. In the latter analysis, the most isolated group of relevés should be ascribed to the *Cypero longi-Caricetum otrubae*, whose syntaxonomic location in the *Phragmito australis-Magnocaricetea elatae* class is the subject of different opinions as will be discussed later. The dendrogram highlights the intermediate position of the *Cladietum marisci* among the communities of the orders *Phragmitetalia australis* and *Magnocaricetalia*.

Overall, according to the results of the cluster analysis and to investigated literature, the Aquila Lake vegetation includes 8 classes and 23 plant communities reported in the syntaxonomic scheme.

Floating aquatic vegetation

(*Lemnetea minoris* Tüxen ex O. Bolòs & Masclans 1955) Tab.2

The most widespread floating aquatic vegetation is the *Lemnetum minoris* that covers the greatest surfaces in the lake (Tab. 2, rels. 3-4). *Lemna minor* is a pleustophyte with a wide ecological amplitude, behaving as a pioneer and able to adapt to strong variations in environmental parameters, with particular regard to the water level and degree of trophy (Sburlino *et al*., 2004), colonizing both ephemeral environments, such as temporary ponds, and permanent water bodies. In the surveyed community *Lemna minuta* also occurs, an alien species recently reported and rapidly expanding in Italy, adapted to waters rich in nutrients and poorly oxygenated (Ceschin *et al*., 2018; Musarella *et al*., 2019).

More localized is the *Lemno minoris-Spirodeletum polyrhizae* (Tab. 2, rels. 1-2), due to changes in the water level that lead to variations in the degree of water trophy. This phytocoenoses is characterized by *Spirodela polyrhiza*, a very rare floating hydrophyte in Calabria. This community occurs in the marginal parts of the marsh vegetation of the lake, in areas with limited anthropic disturbance, with still and non-shaded waters.

Finally, *Lemno minoris-Hydrocharitetum morsus-ranae* (Tab. 2, rels. 5-7), a pleustophytic paucispecific community, characterized by the dominance of *Hydrocharis morsus-ranae*, recently reported in wet habitats of Calabria by Bartolucci *et al*. (2019). In the Aquila Lake, this vegetation is rare and localized in a loop,

Tab. 2 - *Lemnetea minoris*. LS: *Lemno minoris-Spirodeletum polyrhizae*; Lm: *Lemnetum minoris*; LH: *Lemno minoris-Hydrocharitetum morsus-ranae*. Rels. 1-2: 22-05-2008; Rels. 3-4: 12-09-2013; Rel. 5: 12-09-2013; Rel. 6: 30-04-2014; Rel. 7: 13-06-2014.

Community type	LS	LS	Lm	Lm	LH	LH	LH
Relevé number	1	2	3	4	5	6	7
Relevé number (original)	13	13b	89	89b	65	65b	65c
Surface (m^2)	2	2	2	2	10	10	5
Total cover (%)	60	70	70	60	100	100	100
Depth (m)	1	1	2	1	0.5	0.5	0.4
Characteristic species							
Spirodela polyrhiza (L.) Schleid.	2	3	.	.	.	.	.
Lemna minor L.	4	4	4	4	1	2	1
Hydrocharis morsus-ranae L.	.	.	.	.	5	4	4
Ceratophyllum demersum L.	.	.	.	.	3	3	2
Lemna minuta L.	.	.	3	1	.	.	.
Other species							
Persicaria decipiens (R. Br.) K.L. Wilson	.	.	.	.	.	.	+
Potamogeton trichoides Cham. & Schltdl.	.	.	.	.	.	1	.
Number of species	2	2	2	2	3	4	3

in correspondence of the introduction of water coming from a source. This phytocoenosis prefers stagnant or slow-flowing waters, subject to summer heating but not to desiccation. It settles on organic or mineral substrates with mesotrophic to eutrophic, non-shaded waters (Passarge, 1996) having few suspended sediments.

Macrophitic Aquatic vegetation

(*Potametea pectinati* Klika in Klika & Novák 1941) Tab. 3

Most of the lake surface is occupied by *Nymphaeetum albae* (Tab. 3, rels. 1-3), association characterized by rooting hydrophytes with floating leaves (nimpheids), settled on silt-clay sediments rich in organic substance, about 1-2 m deep, in mesotrophic to eutrophic lakes (Šumberová, 2011). The detected stands are poor in species, or even monospecific with the dominace of *Nymphaea alba*, which prefers banks with standing waters, as it is sensitive to the movements of the waves. Communities with *Nymphaea alba*, very rare in southern Italy, are reported for central and northern Italy (Lastrucci *et al*., 2017).

Tab. 3 - *Potametea pectinati*. Na - *Nymphaeetum albae*; Cd - *Ceratophylletum demersi*. Rels. 1-3: 22-05-2008; Rels. 4-6: 22-05-2008; Rel. 7: 27-06-2008.

Community type	Na	Na	Na	Cd	Cd	Cd	Cd
Relevé number	1	2	3	4	5	6	7
Relevé number (original)	24	39	39b	14	15	16	35
Surface (m^2)	10	20	20	100	20	20	20
Total cover (%)	60	100	80	90	100	100	80
Depth (m)	2	2	1.5	2	2.5	2.5	3
Characteristic species							
Nymphaea alba L.	4	4	5	.	2	2	.
Ceratophyllum demersum L.	.	3	1	4	5	4	4
Potamogeton trichoides Cham. & Schltdl.	2	.	.	.	.	.	3
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis	1	.	.	1	.	.	.
Other species							
Chara vulgaris L.	2	.	.	.	.	.	.
Damasonium alisma Mill.	.	.	.	.	.	.	2
Persicaria decipiens (R. Br.) K.L. Wilson	.	.	.	2	.	.	.
Number of species	4	2	2	3	2	2	3

In the central part of the lake, up to 4 m deep, the association *Ceratophylletum demersi* has been detected (Tab. 3, rels. 4-7), a submerged, floating, non-rooted macrophyte community, known in Calabria for the mouth of the Crati River (Maiorca *et al*., 2007), common in the lowland and hilly areas of Europe (Lastrucci *et al*., 2014). *Ceratophyllum demersum* is a pleustophyte that sporadically is associated with rooting hydrophytes (rhizophytes), including *Potamogeton trichoides*. *Ceratophyllum demersum* tolerates water anoxia conditions in summer and strong variations in ecological parameters. It is found in eutrophic lakes due to natural or anthropic causes (Rodwell, 1995), adapting to the shaded conditions due to the floating aquatic vegetation or to the surrounding tree cover (Best & Van Der Werf, 1986).

Perennial helophytic marsh vegetation

(*Phragmito australis-Magnocaricetea elatae* Klika in Klika & Novák 1941)

Along the shores of the Aquila Lake, wetland vegetation dominated by tall helophytes is well developed. According to Landucci *et al*. (2013), this vegetation includes various phytocoenoses, arranged in specific patterns related to the submersion period and the degree of water trophic content.

Reed swamps and other tall helophyte vegetation

(*Phragmitetalia australis* W. Koch 1926) Tab. 4

The most widespread marsh vegetation occurring along the shores of the lake is represented by the reedbeds dominated by *Phragmites australis*, a species with a wide ecological value. The reeds at the Aquila lake are attributable to *Polygono salicifolii-Phragmitetum australis*, a phytocoenosis linked to fresh waters, characterized by *Persicaria decipiens* (= *Polygonum salicifolium*), *Iris pseudacorus*, *Galium elongatum*, and other strictly freshwater marsh species (Tab. 4, rels. 1-8). This phytocoenosis is adapted to even considerable oscillations in the water level and its chemical and physical parameters. It is known for various localities of Sicily (Pavone *et al*., 2007) and Calabria (Maiorca *et al*., 2007).

In the deeper stretches the *Polygono salicifolii-Phragmitetum communis* is replaced by the *Schoenoplectetum lacustris* settled in calm, eutrophic waters

Tab. 4 - *Phragmito australis-Magnocaricetea elatae*, *Phragmitetalia australis*. PP - *Polygono salicifolii-Phragmitetum australis*; Tl - *Typhetum latifoliae*, Sl - *Schoenoplectetum lacustris*. Rels. 1-3: 22-05-2008; Rels. 4-5: 27-06-2008; Rel. 6: 26-07-2013; Rels. 7-8: 12-09-2013; Rel. 9: 22-05-2008; Rel. 10: 12-09-2013; Rel. 11: 22-05-2008; Rel. 12: 27-06-2008; Rel. 13: 26-07-2013; Rels. 14-15: 12-09-2013; Rel. 16: 13-06-2014.

Community type	PP	PP	PP	PP	PP	PP	PP	PP	Tl	Tl	Sl	Sl	Sl	Sl	Sl	Sl
Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Relevé number (original)	1	2	3	21	31	46	49	50	8	52	20	30	44	55	56	83
Surface (m^2)	50	50	50	20	5	20	20	20	10	10	20	20	20	20	20	20
Total cover (%)	100	100	100	100	100	100	100	100	100	100	90	100	100	100	100	100
Depth (m)	1	1	1	1	0.5	0.5	0.4	0.4	0.5	0.5	1	1	1.5	1.5	1	1.5
Characteristic species																
Persicaria decipiens (R. Br.) K.L. Wilson	.	.	.	3	1	2	2	1	.	.	1	1	.	1	.	2
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis	5	5	5	5	5	5	5	5	.	1	3	1	1	2	3	2
Typha latifolia L.	.	.	.	.	.	.	.	.	4	4	2	1	.	.	.	.
Schoenoplectus lacustris (L.) Palla	.	.	.	.	.	.	.	.	.	.	5	5	5	5	4	5
Agrostis stolonifera L. subsp. scabriglumis (Boiss. & Reut.) Maire	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Convolvulus sepium L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Convolvulus silvaticus Kit.	.	1	.	.	2	2	.	.	.	.	.	.	.	.	.	.
Carex acutiformis Ehrh.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.
Carex riparia Curtis	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.
Cirsium creticum (Lam.) d'Urv. subsp. triumfetti (Lacaita) K. Werner	.	1	1	.	.	.	.	1	.	.	.	.	.	.	.	.
Epilobium hirsutum L.	1	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.
Equisetum ramosissimum Desf.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Equisetum telmateia Ehrh.	.	.	.	.	1	.	.	.	2	.	.	.	.	.	.	.
Eupatorium cannabinum L. subsp. cannabinum	.	2	2	.	.	.	1	.	.	.	.	.	.	+	.	.
Galium palustre L. subsp. elongatum (C. Presl) Lange	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Hypericum tetrapterum Fr.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Juncus conglomeratus L.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Lycopus europaeus L.	1	1	1	.	+	.	.	1	.	2	.	.	.	1	+	1
Lythrum salicaria L.	.	.	1	.	.	1	2	1	.	.	.	.	.	.	.	.
Mentha suaveolens Ehrh. subsp. suaveolens	.	2	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Rumex sanguineus L.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Solanum dulcamara L.	.	1	1	.	.	2	2	1	.	.	.	.	.	.	.	.
Sparganium erectum L.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Other species																
Epilobium hirsutum L.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Equisetum telmateia Ehrh.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Paspalum distichum L.	2	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Pulicaria dysenterica (L.) Bernh.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Rubus ulmifolius Schott	1	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Salix alba L.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Symphyotrichum squamatum (Spreng.) G.L. Nesom	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Number of species	5	9	9	2	9	6	6	7	4	6	5	4	3	5	3	5

more than 30 cm deep on muddy or sandy bottoms, generally with little organic sediment (Lastrucci *et al*., 2014). Along the inner side of the lake, the *Schoenoplectetum lacustris* (Tab. 4, rels. 11-16) makes contact with the macrophytic vegetation of the *Nimphaeetum albae*.

In more disturbed areas of the banks, due to plant residues accumulation, as well as in the drainage channels of the cultivated areas adjacent to the lake, the *Typhetum latifoliae* grows (Tab. 4, rels. 9-10), a plant community linked to marsh habitats impacted by anthropic action with soils and waters rich in nutrients.

Tall sedges marsh vegetation

(*Magnocaricetalia* Pignatti 1953) Tab. 5

In the outermost belt of the marsh vegetation, submerged only in the winter period during the maximum lake filling, the high sedges vegetation occurs. Currently, this vegetation is fragmented due to anthropic pressures, such as drainage and modification of banks, related to the increasing of cultivated areas. Variations in groundwater level and flooding time influence the presence of different phytocoenoses.

In the innermost part of the sedges belt the *Caricetum acutiformis* grows (Tab. 5, rels. 1-8), characterized by the dominance of *Carex acutiformis*, a species 1.4-1.6 m high, which demands soils affected by superficial groundwater even in summer.

To the outside, this community makes direct contact with the *Caricetum ripariae* (Tab. 5, rels. 9-13), growing on soils flooded for a shorter period.

A floating bed of *Cladietum marisci* (Tab. 5, rels. 16-21) occupies the west margin of the lake. *Cladium mariscus* develops its rhizomes on the waters of the

Tab. 5 - *Phragmito australis-Magnocaricetea elatae*, *Magnocaricetalia elatae*. Ca - *Caricetum acutiformis*; Cr - *Caricetum riparia*; CC - *Cypero-Caricetum cuprinae*; Cm - *Cladietum marisci*. Rel. 1: 22-05-2008; Rels. 2-4: 27-06-2008; Rels. 5-9: 12-09-2013; Rel. 10: 13-06-2014; Rel. 11: 30-04-2014; Rels. 12-13: 12-09-2013; Rels. 14-15: 13-06-2014; Rels. 16-19: 22-05-2008; Rel. 20: 27-06-2008; Rel. 21: 13-06-2014.

Community type	Ca	Ca	Ca	Ca	Ca	Ca	Ca	Ca	Cr	Cr	Cr	Cr	Cr	CC	CC	Cm	Cm	Cm	Cm	Cm	Cm
Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Relevé number (original)	11	27	28	29	59	60	68	66	67	80	76	51	57	36	37	12	17	18	19	34	38
Surface (m^2)	20	20	20	20	20	20	10	10	10	10	20	20	20	20	20	50	20	20	20	20	20
Total cover (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	80	100	90
Characteristic species																					
Carex acutiformis Ehrh.	5	5	5	5	5	5	4	5	4	3	.	.	.	.	.	.	.	.	.	.	.
Carex riparia Curtis	.	.	.	.	.	.	.	3	4	4	5	4	5	.	.	.	.	.	.	.	.
Carex otrubae Podp.	.	.	.	.	.	.	.	.	.	1	.	.	.	4	2	.	.	.	.	.	.
Cyperus longus L.	.	.	.	+	.	.	.	.	.	.	.	.	.	3	4	.	.	.	.	.	.
Cladium mariscus (L.) Pohl	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	5	5	4	5	4
Thelypteris palustris Schott	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	3	3	.
Phragmites australis (Cav.) Trin. ex Steud.	1	1	.	1	2	.	2	.	1	2	2	.	2	2	1	3	.	1	1	1	3
Convolvulus sepium L.	.	.	.	.	1	1	.	2	2	.	.	.	2	.	.	.	.	.	.	.	.
Convolvulus silvaticus Kit.	1	.	.	.	.	.	.	.	.	1	.	.	.	3	2	.	.	.	.	.	.
Epilobium hirsutum L.	.	2	1	.	.	.	1	+	+	.	1	.	.	1	.	.	.	.	1	.	.
Epilobium tetragonum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Equisetum telmateia Ehrh.	.	.	.	1	.	.	.	1	.	2	.	.	.	+	1	.	.	.	.	.	.
Euphorbia hirsuta L.	1	.	.	.	.	.	.	.	.	2	.	.	2	1	3	.	.	.	.	.	.
Hypericum tetrapterum Fr.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lotus tenuis Waldst. & Kit. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.
Lythrum salicaria L.	.	.	1	.	2	1	.	.	.	.	.	2	.	.	.	.	.	.	.	1	.
Mentha suaveolens Ehrh. subsp. suaveolens	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Persicaria decipiens (R. Br.) K.L. Wilson	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Potentilla reptans L.	.	.	.	.	2	.	.	3	.	2	.	.	.	.	1	.	.	.	.	.	.
Pulicaria dysenterica (L.) Bernh.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex sanguineus L.	.	+	+	1	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.
Schoenoplectus lacustris (L.) Palla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.
Solanum dulcamara L.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																					
Torilis arvensis (Huds.) Link subsp. arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Symphyotrichum squamatum (Spreng.) G.L. Nesom	.	.	.	.	1	.	.	.	.	.	.	.	1	2	3	.	.	.	.	.	.
Lotus rectus L.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eupatorium cannabinum L. subsp. cannabinum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Trifolium squamosum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	.
Hypericum hircinum L. subsp. majus (Aiton) N. Robson	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Poa trivialis L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Equisetum hyemale L.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Holcus lanatus L.	.	1	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	.	.	.
Polypogon monspeliensis (L.) Desf.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.
Atriplex prostrata Boucher ex DC.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Number of species	5	5	4	4	8	7	3	5	4	9	3	4	5	12	12	3	2	3	5	4	3

lake and forms a dense floating bed, poor in species. Among the few species present, *Thelypteris palustris* can be mentioned, known in Calabria only for this locality (Crisafulli *et al*., 2010). This rare fern, typical of the swampy *Alnus glutinosa* woods (Biondi & Blasi, 2015), is also known for occurring in *Cladietum marisci* stands (Namura-Ochalska, 2005), as well as in other marsh associations, such as the *Thelypterido palustris-Phragmitetum australis* (Lastrucci *et al*., 2014). In the coastal lagoons of the Mediterranean basin, *Cladium mariscus* characterizes subalophilic communities, such as the *Soncho-Cladietum marisci* (Br.-Bl. & O. Bolós 1957) Cirujano 1980, reported in Sicily (Pavone *et al*., 2007) and in Apulia (Di Pietro *et al*., 2009). As highlighted also by the classification of the relevés, *Cladietum marisci* is a plant community with intermediate floristic characteristics between the orders *Magnocaricetalia* and *Phragmitetalia*.

In the moat elevated range of the sedge vegetation, the *Cypero-Caricetum cuprinae* (= *Cypero-Caricetum otrubae* Tüxen in Tüxen & Oberdorfer 1958) occurs (Tab. 5, rels. 14-15). The syntaxonomic position of this association is not unanimous. Some authors place it in the alliance *Magnocaricion elatae* of the *Phragmito australis-Magnocaricetea elatae* class (Venanzoni *et al*., 2018), others in the alliance *Mentho longifoliae-Juncion inflexi* Müller & Görs ex de Foucault 2008 of the *Agrostietea stoloniferae* Oberdorfer 1983 class (Lastrucci *et al*., 2014). In fact, the cluster analysis (Fig. 4) separates this community from other sedges coenoses, showing an intermediate position between the marsh vegetation and the wet meadows.

Marsh vegetation of well-oxygenated flowing freshwater

(*Nasturtio officinalis-Glycerietalia fluitantis*) Tab. 6

In the lake's small tributaries fed by perennial springs the *Helosciadietum nodiflori* is present, a plant community linked to shallow, well oxygenated running waters, sunny and constant throughout the year (Tab. 6, rels. 3-4). This plant community is characterized by the dominance of *Helosciadium nodiflorum*, normally associated with a few other hydrophytes as *Veronica anagallis-aquatica*.

In the loops of the lake with low-flowing waters due to small tributaries, the *Sparganietum erecti* has been detected, a helophytic community growing in 50-70 cm deep water, characterized by the dominance of *Sparganium erectum*, associated with *Phragmites australis* and a few other helophytes (Tab. 6, rels. 1-2).

Wet meadow vegetation

(*Molinio-Arrhenatheretea* Tüxen 1937) Tab. 7

The vegetation of the wet meadows settled on moist soils outside the marshes of the surveyed area is very disturbed and fragmented by agricultural activities and pasturage. Some phytocoenoses can be identified as *Cirsio triumfetti-Eupatorietum cannabini* (Tab. 7, rels. 3-4) on more humid stands, which take advantage of the accumulation of organic materials, and *Alopecurus myosuroides* community (Tab. 7, rels. 5-6) growing in the most external surfaces on flat muddy-clayey soils, periodically flooded and grazed. Finally, a community with *Althaea officinalis* occurs in the more disturbed sites (Tab. 7, rels. 1-2).

Tab. 6 - *Phragmito australis-Magnocaricetea elatae*, *Nasturtio officinalis-Glyceretalia flutantis*. Se - *Sparganietum erecti*; Hn - *Helosciadietum nodiflori*. Rels. 1-2: 22-05-2008; Rels. 3-4: 26-07-2013.

Community type	Se	Se	Hn	Hn
Relevé number	1	2	3	4
Relevé number (original)	22	23	7	7b
Surface (m^2)	10	10	10	10
Total cover (%)	100	100	90	100
Depth (m)	1	0.5	0.3	0.3
Characteristic species				
Sparganium erectum L.	5	5	1	1
Helosciadium nodiflorum (L.) W.D.J. Koch	.	.	4	5
Veronica anagallis-aquatica L.	.	.	2	1
Persicaria decipiens (R. Br.) K.L. Wilson	2	3	.	.
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis	.	1	.	.
Other species				
Paspalum distichum L.	.	.	1	+
Solanum dulcamara L.	.	.	1	.
Number of species	2	3	5	3

Tab. 7 - *Molinio-Arrhenatheretea*. Ao: *Althaea officinalis* community, CE: *Cirsio triumfetti-Eupatorietum cannabini*, Am: *Alopecurus myosuroides* community. Rels. 1-2: 26-07-2013; Rels. 3-4: 12-09-2013; Rels. 5-6: 13-06-2014.

Community type	Ao	Ao	CE	CE	Am	Am
Relevé number	1	2	3	4	5	6
Relevé number (original)	45	61	48	48b	69	25
Surface (m^2)	20	50	20	30	20	20
Total cover (%)	100	100	100	100	100	90
Characteristic species						
Althaea officinalis L.	3	2	.	.	.	.
Cirsium creticum (Lam.) d'Urv. subsp. triumfetti (Lacaita) K. Werner	.	.	3	4	.	.
Eupatorium cannabinum L. subsp. cannabinum	.	.	3	2	.	.
Alopecurus myosuroides Huds.	.	.	.	.	2	4
Lythrum salicaria L.	4	3	.	.	.	.
Mentha longifolia (L.) L.	3	.	.	.	.	.
Daucus carota L. subsp. carota	1	2	.	.	1	.
Pulicaria dysenterica (L.) Bernh.	3	4	1	.	.	.
Holcus lanatus L.	1	.	.	.	2	+
Potentilla reptans L.	.	2	.	.	3	.
Trifolium repens L.	1	2	.	.	1	3
Carex otrubae Podp.	.	.	.	1	.	2
Lotus rectus L.	.	.	3	2	1	.
Lythrum junceum Banks & Sol.	.	.	2	.	.	1
Mentha suaveolens Ehrh. subsp. suaveolens	.	1	2	1	.	.
Ajuga reptans L.	.	.	.	.	+	.
Agrostis stolonifera L. subsp. scabriglumis (Boiss. & Reut.) Maire	.	.	.	.	1	3
Equisetum telmateia Ehrh.	.	.	1	1	.	.
Convolvulus sepium L.	1	.	.	.	.	.
Geranium dissectum L.	.	.	.	.	2	.
Lolium perenne L.	.	.	.	.	1	3
Lotus tenuis Waldst. & Kit. ex Willd.	.	1	.	.	.	.
Oenanthe pimpinelloides L.	.	.	.	.	2	3
Poa trivialis L.	.	.	.	.	3	2
Ranunculus neapolitanus Ten.	.	.	.	1	.	1
Mentha aquatica L.	.	.	.	.	.	1
Plantago major L.	.	.	.	.	.	+
Other species						
Samolus valerandi L.	.	.	2	.	.	.
Lathyrus aphaca L.	.	.	.	.	.	1
Carex acutiformis Ehrh.	1	.	.	.	.	.
Carex riparia Curtis	.	.	.	.	.	1
Typha latifolia L.	.	.	2	1	.	.
Cynodon dactylon (L.) Pers.	.	.	.	.	1	3
Vicia bithynica (L.) L.	.	.	.	.	.	1
Bromus hordeaceus L.	.	.	.	.	1	2
Xanthium italicum Moretti	.	.	.	.	+	.
Symphyotrichum squamatum (Spreng.) G.L. Nesom	.	.	1	+	.	.
Poa annua L.	.	.	.	.	1	.
Ranunculus arvensis L.	.	.	.	.	+	.
Bellardia viscosa (L.) Fisch. & C.A. Mey.	.	.	.	.	.	1
Number of species	9	8	10	8	14	16

Hygro-nitrophilous, megaphorbs vegetation

(*Filipendulo ulmariae-Convolvuletea sepium* Géhu & Géhu-Franck 1987) Tab. 8

In areas heavily disturbed such as lake banks and canals, *Arundo donax* communities occur, attributable to the *Calystegio silvaticae-Arundinetum donacis* (Tab. 8), a hygro-nitrophilous association described by Brullo *et al*. (2001) for southern Calabria. *Arundo donax* is an alien invasive species (Galasso *et al*. 2018) introduced long time ago throughout the Mediterranean. This vegetation, known in other regions too,

Tab. 8 - *Filipendulo ulmariae-Convolvuletea sepium*. *Calystegio silvaticae-Arundinetum donacis*. Rel. 1: 22-05-2008; Rel. 2: 12-09-2013; Rel. 3: 13-06-2014.

Community type	CA	CA	CA
Relevé number	1	2	3
Relevé number (original)	6	58	79
Surface (m^2)	20	50	20
Total cover (%)	100	100	100
Characteristic species			
Arundo donax L.	5	5	5
Rubus ulmifolius Schott	2	3	+
Convolvulus silvaticus Kit.	2	.	2
Equisetum telmateia Ehrh.	.	1	1
Urtica dioica L.	.	2	2
Arum italicum Mill.	.	.	1
Clematis vitalba L.	.	2	.
Galium aparine L.	.	.	1
Other species			
Mentha suaveolens Ehrh. subsp. suaveolens	1	.	.
Sambucus ebulus L.	.	.	1
Torilis arvensis (Huds.) Link subsp. arvensis	.	.	+
Number of species	4	5	7

replaces the wet meadow and marsh vegetation. It is a thermophylous vicariant of the *Arundini-Convolvuletum sepium*, a community widely distributed in the Euro-Mediterranean territories (Giusso del Galdo *et al*., 2008).

Riparian woods

(*Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantó ex Rivas-Martínez, *et al*. 2001) Tab. 9

The riparian and lowland woods, which probably covered the shores of the lake in former times, are nowadays reduced to small patches as a result of land use changes due to agriculture and plantation of hybrid poplars (*Populus* x *canadensis*), realized some decades ago on the western shore of the lake (Tab. 9, rels. 9-11).

Only very limited patches remain, on the right bank of the lake, characterized by the dominance of *Alnus glutinosa* (Tab. 9, rel. 5), to which other hygrophilous species are associated, including the very rare *Iris foetidissima*, a typical species of these habitats (Brullo & Spampinato, 1997).

High-shrub willows of *Salicetum albo-brutiae* form small patches in the northern part of the lake (Tab. 9, rels. 1-4). It is a pioneer plant community characterized by the codominance of *Salix alba* and *Salix brutia*, spread along the waterways of the region (Brullo & Spampinato, 1997).

Small patches or dense hedgerows of *Ulmus minor*, referable to the *Aro italici-Ulmetum minoris*, are still present on sandy or muddy soils in the most external parts of the lake zonation, occasionally flooded but provided with water reserves for most of the year (Tab. 9, rels. 6-8).

Shrubby communities

(*Rhamno catharticae-Prunetea spinosae* Rivas Goday & Borja ex Tüxen 1962) Tab. 10

In more elevated positions of the lake shores, shrub communities dominated by deciduous species such as *Cornus sanguinea* and *Rubus ulmifolius* occur. They are secondary formations originating from the riparian wood's degradation.

Mesophylous woods

(*Querco roboris-Fagetea sylvaticae*) Tab. 11

Despite the surrounding land being very degraded by anthropic pressures, residual patches of mesophylous woods grow on the northern hillside slopes. The tree layer is structured by species of particular value because they live at the limit of their distribution range, such as *Tilia platyphyllos* subsp. *pseudorubra* and *Quercus robur* subsp. *brutia*. To date, this latter species was not known for the province of Reggio Calabria and it is very rare in the region, growing in residual planitial forest of the *Alno-Quercion roboris* (Brullo & Spampinato, 1999). The nemoral flora is rich in species normally found in the mountain belt, such as *Helleborus bocconei* subsp. *intermedius*, *Lathyrus venetus*, *Euphorbia meuselii*. In the past, these formations were certainly much more articulated and diversified in various plant communities, according to topographical and edaphic characteristics. The current situation, in which only two patches are present, makes their phytosociological classification very difficult and, at the moment, still uncertain.

Habitats of conservation interest

The European Directive 92/43/EEC (Habitat Directive) is one of the main regulatory instruments for the conservation of biodiversity in Europe. The main goal of this Directive is the conservation of species and habitats of community interest through the Natura 2000 ecological network. Habitats listed in Annex I are identified mainly on a phytosociological basis (Biondi *et al*., 2009, 2012). Therefore, the phytosociological study of vegetation is necessary to diagnose and assess the habitats of Annex I and plan the management of natural resources (Gigante *et al*., 2016, 2018; Zivkovic *et al*., 2017).

Based on Biondi *et al*. (2009), this study allowed the identification of four Annex I habitats at Lake Aquila. They are reported as follows and related to the analysed plant communities:

- 3150: Natural euthrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (*Lemnetum minoris* Oberdorfer ex Müller & Görs 1960; *Lemno-Spirodeletum polyrhizae* Koch 1954; *Lemno minoris-Hydrocharitetum morsus-ranae* Passarge 1978;

Tab. 9 - *Salici purpureae-Populetea nigrae*. Sa: *Salicetum albo-brutiae*; Ag: *Alnus glutinosa* community; AU: *Aro italici-Ulmetum minoris*; Pp: Poplar plantations. Rel. 1: 22-05-2008; Rel. 2: 27-06-2008; Rels. 3-4: 12-09-2013; Rel. 5: 13-06-2014; Rels. 6-7: 12-09-2013; Rel. 8: 30-04-2014; Rels. 9-10: 22-05-2008; Rel. 11: 13-06-2014.

Community type	Sa	Sa	Sa	Sa	Ag	AU	AU	AU	Pp	Pp	Pp
Relevé number	1	2	3	4	5	6	7	8	9	10	11
Relevé number (original)	10	53	64	84	33	62	63	78	4	5	82
Surface (m^2)	100	100	100	50	100	100	100	50	34	34	36
Total cover (%)	100	90	100	100	100	100	90	70	100	100	100
Characteristic species											
Salix alba L.	4	4	5	3	3	.	.	.	.	.	2
Salix brutia Brullo & Spamp.	3	3	3	3	.	.	.	.	.	.	.
Alnus glutinosa (L.) Gaertn.	.	.	.	.	3	.	.	.	.	.	.
Ulmus minor Mill.	.	.	.	.	2	5	4	4	.	.	.
Arum italicum Mill.	.	.	.	.	+	2	1	.	.	.	.
Populus x canadensis Moench	.	2	.	.	.	.	.	.	5	5	4
Equisetum telmateia Ehrh.	1	.	1	.	.	.	.	+	.	.	.
Hypericum hircinum L. subsp. majus (Aiton) N. Robson	2	1	.	.	.	.	.	.	2	1	.
Carex pendula Huds.	.	.	2	.	.	.	.	.	.	.	.
Cornus sanguinea L.	.	.	.	1	.	1	.	3	1	.	.
Solanum dulcamara L.	2	1	2	.	.	.	.	.	.	.	.
Euphorbia meuselii Geltman	+	.	.	.	.	.	.	.	.	.	.
Brachypodium sylvaticum (Huds.) P. Beauv.	.	.	.	.	.	1	.	.	.	.	.
Aegonychon purpurocaeruleum (L.) Holub	.	.	.	.	.	.	.	+	.	.	.
Clematis vitalba L.	.	.	.	.	2	2	.	2	2	1	2
Hedera helix L. (e)	.	.	.	.	.	3	1	.	.	.	.
Iris foetidissima (L.) Medik.	.	.	.	.	1	1	1	.	.	.	.
Sambucus nigra L.	.	.	.	.	2	.	.	.	.	.	.
Vinca major L.	.	.	.	.	.	.	2	2	.	.	.
Other species											
Arisarum vulgare O. Targ.Tozz.	.	.	.	.	.	+	.	.	.	.	.
Arundo donax L.	.	.	.	.	.	.	.	.	2	1	.
Asparagus acutifolius L.	.	.	.	.	.	1	+	1	.	.	.
Bryonia dioica Jacq.	.	.	.	.	2	.	.	.	.	.	.
Carex riparia Curtis	.	.	.	.	1	.	.	.	.	.	.
Cirsium creticum (Lam.) d'Urv. subsp. triumfetti (Lacaita) K. Werner	.	.	.	.	.	.	.	.	1	.	.
Convolvulus silvaticus Kit.	1	.	.	.	.	.	.	.	.	.	.
Daucus carota L. subsp. carota	.	.	.	.	.	.	.	.	.	.	1
Equisetum palustre L.	2	.	.	.	.	.	.	.	.	.	.
Euonymus europaeus L.	.	.	.	.	.	1	.	.	.	.	.
Eupatorium cannabinum L. subsp. cannabinum	1	.	.	.	.	.	.	.	.	.	.
Foeniculum vulgare Mill. subsp. piperitum (Ucria) Bég.	.	.	.	.	.	.	.	.	.	.	1
Fraxinus ornus L.	.	.	.	.	.	2	.	.	.	.	.
Lotus rectus L.	1	.	.	.	.	.	.	.	.	.	.
Myrtus communis L.	.	.	.	.	.	.	.	1	.	.	.
Persicaria decipiens (R. Br.) K.L. Wilson	.	.	1	.	.	.	.	.	.	.	.
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis	3	.	.	2	.	1	1	.	1	1	.
Pteridium aquilinum (L.) Kuhn	.	.	.	.	.	.	.	1	.	.	.
Robinia pseudoacacia L.	.	.	.	.	.	.	.	.	.	2	.
Rosa sempervirens L.	.	.	.	.	.	2	1	1	.	.	.
Rubia peregrina L.	.	.	.	.	.	1	.	3	.	.	.
Rubus ulmifolius Schott	.	.	.	.	.	.	.	.	.	.	.
Smilax aspera L.	.	.	.	.	.	.	2	2	.	.	.
Urtica dioica L.	.	.	1	.	.	.	.	.	1	.	.
Verbena officinalis L.	+	.	.	.	.	.	.	.	.	.	.
Number of species	10	5	7	4	8	13	8	10	8	6	5

Nymphaeetum albae Vollmar 1947 em. Oberd. in Oberd. & Mitarb. 1967; *Ceratophylletum demersi* Hild 1956);
- 3260: Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (*Apietum nodiflori* Br.-Bl. (1931) 1952);
- 7210*: Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (*Cladietum marisci* Allorge 1921);
- 6420 Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion* (*Cirsio triumfettii-Eupatorietum cannabini* Brullo & Spampinato 1990).

Tab. 10 - *Rhamno catharticae-Prunetea spinosae*. *Rubus ulmifolius* community. Rel. 1: 22-05-2008; Rel. 2: 26-07-2013; Rel. 3: 12-09-2013.

Relevé number	1	2	3
Relevé number (original)	7	41	54
Surface (m^2)	20	20	50
Total cover (%)	100	100	100
Characteristic species			
Rubus ulmifolius Schott	5	5	4
Convolvulus silvaticus Kit.	2	2	.
Clematis vitalba L.	.	3	2
Arundo collina Turra	1	.	.
Cornus sanguinea L.	.	.	4
Ficus carica L.	.	.	1
Galium aparine L.	1	.	.
Other species			
Solanum dulcamara L.	2	+	.
Equisetum telmateia Ehrh.	1	.	.
Eupatorium cannabinum L. subsp. cannabinum	.	.	1
Hypericum hircinum L. subsp. majus (Aiton) N. Robson	.	2	.
Persicaria decipiens (R. Br.) K.L. Wilson	.	.	+
Phytolacca americana L.	+	.	.
Pteridium aquilinum (L.) Kuhn	.	1	.
Quercus virgiliana (Ten.) Ten. (a)	.	1	.
Raphanus raphanistrum L. subsp. landra (Moretti ex DC.) Bonnier & Layens	1	.	.
Rosa sempervirens L.	.	.	1
Silene latifolia Poir.	+	.	.
Number of species	7	6	6

Among these, the priority habitat 7210* (Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*) has particular importance, being very rare in the Mediterranean bioregion and present in Calabria only in another site (Maiorca *et al*., 2002).

Conclusions

Despite many anthropogenic pressures, the Aquila Lake harbours aquatic and marsh plant communities rather rare in the Mediterranean bioregion, such as the macrophytic vegetation of *Nymphaeetum albae*, the floating aquatic vegetation of *Lemno minoris-Hydrocharitetum morsus-ranae* and the tall sedges marsh vegetation of *Cladietum marisci*, all acknowledged as Annex I habitats deserving conservation efforts. The lake is a refuge site for many taxa with a northern distribution that disappeared from the surrounding territories, due to climate change and reclamations carried out in the last centuries, such as *Thelypteris palustris*, *Cladium mariscus*, *Schoenoplectus lacustris*, *Hydrocharis morsus-ranae*, *Nymphaea alba* subsp. *alba* and *Quercus robur* subsp. *brutia*.

The rarity of these species and habitats suggests the need of proper management guidelines aimed at the protection and conservation of the biotope, both through the maintenance of existing natural features

Tab. 11 - *Querco roboris-Fagetea sylvaticae*. Rels. 1-2: 27-06-2008; Rels. 3-4: 26-07-2013.

Relevé number	1	2	3	4
Relevé number (original)	32	42	43	76
Surface (m^2)	45	45	50	50
Total cover (%)	100	200	200	100
Cover Tree layer (A) (%)	90	100	100	100
Cover Scrub layer (a) (%)	80	40	40	40
Cover Herb layer (e) (%)	80	80	80	60
Slope (°)	80	50	50	40
Exposition	N	N	N	N
Characteristic species				
Ostrya carpinifolia Scop.	4	5	5	4
Acer opalus Mill. subsp. obtusatum	2	2	3	2
Quercus robur L. subsp. brutia (Ten.) O. Schwarz	2	2	.	2
Cornus sanguinea L.	3	2	1	2
Fraxinus ornus L. subsp. ornus	2	3	2	2
Vinca major L.	2	.	2	2
Helleborus viridis L. subsp. bocconei (Ten.) Peruzzi	1	.	2	2
Hedera helix L. (A)	3	2	1	.
Hedera helix L. (e)	3	3	2	.
Brachypodium sylvaticum (Huds.) P. Beauv.	1	1	2	.
Lathyrus venetus (Mill.) Wohlf.	+	.	1	2
Ulmus minor Mill.	.	1	1	.
Viola alba Besser subsp. dehnhardtii (Ten.) W. Becker	1	.	.	1
Euphorbia meuselii Geltman	1	.	.	2
Polystichum setiferum (Forssk.) T. Moore ex Woyn.	.	+	1	.
Tilia platyphyllos Scop. subsp. pseudorubra C.K. Schneid.	3	.	.	.
Castanea sativa Mill.	.	1	.	.
Symphytum bulbosum K.F. Schimp.	.	.	.	1
Drymochloa drymeja (Mert. & W.D.J. Koch) Holub	.	.	.	4
Festuca heterophylla Lam.	.	.	2	.
Acer campestre L.	.	1	.	.
Other species				
Rubia peregrina L.	1	2	2	2
Asparagus acutifolius L.	1	1	1	.
Clematis vitalba L.	2	2	2	.
Cytisus villosus Pourr.	2	2	2	.
Crataegus monogyna Jacq.	1	1	.	.
Chamaeiris foetidissima (L.) Medik.	1	.	.	+
Luzula forsteri (Sm.) DC.	.	+	1	.
Pteridium aquilinum (L.) Kuhn	1	.	.	1
Quercus ilex L.	2	.	1	.
Rosa sempervirens L.	.	1	+	.
Rubus ulmifolius Schott	.	2	1	.
Smilax aspera L.	1	2	.	.
Asplenium onopteris L.	.	1	.	.
Aegonychon purpurocaeruleum (L.) Holub	.	.	.	+
Cyclamen hederifolium Aiton	.	.	.	+
Carex distachya Desf.	.	1	.	.
Arundo plinii Turra	.	.	1	.
Euonymus europaeus L.	1	.	.	.
Hypericum hircinum L. subsp. majus (Aiton) N. Robson	.	.	.	1
Ruscus aculeatus L.	.	1	.	.
Number of species	23	22	21	15

and by operating with environmental restoration activities on degraded stretches through specific projects.

The Aquila Lake has not yet been included neither in any list of protected areas nor in sites of significant naturalistic or environmental importance. This study fills a knowledge gap to carry out forms of protection in this fragile and valuable biotope, threatened by agro-pastoral activities practiced in the surrounding territory.

The most serious threat to aquatic and marsh habitats

is the terrestrialization processes, which over time has reduced the lake surface to the advantage of cultivated areas. In addition, the run-off of fertilizers, pesticides and herbicides that could pollute the aquifer has negative consequences on species and habitats linked to the wetland, more susceptible to the effects of pollutants.

According to Quinto-Canas *et al*. (2018b), in order to maintain a good level of biodiversity, it is necessary to reduce the use of herbicides and fertilizers, to avoid soil mobilization and to control or eradicate non-native plants. The last ones often grow mixed with the native ones and can replace them (Musarella, 2019).

Floristic and palynologic studies, but also the toponymy and archaeological evidence (Russo *et al*., 2018, Spampinato *et al*., 2007; 2017), highlight that the landscape of the lowland area of Calabria in the Holocene has been strongly modified by human activities. A drastic reduction of floodplain forests and wetland, up to their disappearance, due to the expanding of agricultural and settlement areas. The few relict wetland areas in the lowland, therefore, have high importance for biodiversity conservation.

Due to the importance of this peculiar biotope, we consider that specific conservation measures need to be taken in order to preserve its flora and vegetation. These conservation measures should also take into account bio-climatological features, because only considering bioclimate, it is possible to guarantee a correct management of biodiversity (Cano-Ortiz *et al*., 2015a, b; Cano *et al*., 2019).

Acknowledgements

We are very grateful to Dr. Giovanna Belmusto and Dr. Letteria Settineri of the Waters Thematic Service of the Provincial Department ARPACAL of Reggio Calabria (Italy) to have carried out the sampling and for the chemical and physical analysis of the lake waters.

Syntaxonomic scheme

LEMNETEA MINORIS Tüxen ex O. Bolòs & Masclans 1955
LEMNETALIA MINORIS Tüxen ex O. Bolòs & Masclans 1955
Lemnion minoris Tüxen ex O. Bolòs & Masclans 1955
Lemnetum minoris Oberdorfer ex Müller & Görs 1960
Lemno minoris-Spirodeletum polyrhizae Koch 1954
Lemno minoris-Hydrocharition morsus-ranae Rivas-Martínez, Fernández-Gonzáles et Loidi 1999
Lemno minoris-Hydrocharitetum morsus-ranae Passarge 1978

POTAMETEA PECTINATI Klika in Klika & Novák 1941
POTAMETALIA PECTINATI W. Koch 1926
Nymphaeion albae Oberdorfer 1957
Nymphaeetum albae Vollmar 1947 em. Oberd. in Oberd. *et al*. 1967
UTRICULARIETALIA Den Hartog & Segal 1964
Ceratophyllion demersi Den Hartog & Segal ex Passarge 1996
Ceratophylletum demersi Hild 1956

PHRAGMITO AUSTRALIS-MAGNOCARICETEA ELATAE Klika in Klika & Novák 1941
PHRAGMITETALIA AUSTRALIS W. Koch 1926
Phragmition australis W. Koch 1926
Polygono salicifolii-Phragmitetum australis Barbagallo, Brullo et Furnari 1979
Typhetum latifoliae Nowiński 1930
Schoenoplectetum lacustris Chouard 1924
MAGNOCARICETALIA ELATAE Pignatti 1954
Magnocaricion elatae Koch 1926
Cladietum marisci Allorge 1921
Caricetum acutiformis Eggler 1933
Caricetum ripariae Máthé et Kovács 1959
Cypero-Caricetum cuprinae Tüxen & Oberdorfer ex T.E. Díaz 1975
NASTURTIO OFFICINALIS-GLYCERIETALIA FLITANTIS Pignatti 1953
Glycerio fluitantis-Sparganion neglecti Br.-Bl. et Sissingh in Boer 1942
Sparganietum erecti Philippi 1973

Apion nodiflori Segal in Westhoff et Den Held 1969
Helosciadietum nodiflori Maire 1924

MOLINIO-ARRHENATHERETEA Tüxen 1937
PLANTAGINETALIA MAJORIS Tüxen ex Von Rochow 1951
Lolio perennis-Plantaginion majoris Sissingh 1969
Cirsio triumfettii-Eupatorietum cannabini Brullo et Spampinato 1990
Community of *Alopecurus aequalis*

FILIPENDULO ULMARIAE-CONVOLVULETEA SEPIUM Géhu & Géhu-Franck 1987
CALYSTEGIETALIA SEPIUM Tüxen ex Mucina 1993 nom. mut. propos. Rivas-Martínez, *et al*. 2002
Calystegion sepium Tüxen ex Oberdorfer 1957 nom. mut. propos. Rivas-Martínez *et al*. 2002
Calystegio silvaticae-Arundinetum donacis Brullo, Scelsi et Spampinato 2001
Community of *Althaea officinalis*

SALICI PURPUREAE-POPULETEA NIGRAE Rivas-Martínez & Cantó ex Rivas-Martínez, *et al*. 2001
POPULETALIA ALBAE Br.-Bl. ex Tchou 1948
Populion albae Br.-Bl. ex Tchou 1948
Community of *Alnus glutinosa*
Aro italici-Ulmetum minoris Rivas-Martinez ex López 1976
SALICETALIA PURPUREAE Moor 1958
Salicion albae Soó 1930
Salicetum albo-brutiae Brullo & Spampinato 1997

RHAMNO CATHARTICAE-PRUNETEA SPINOSAE Rivas Goday & Borja ex Tüxen 1962
PYRO SPINOSAE-RUBETALIA ULMIFOLII Biondi, Blasi & Casavecchia in Biondi *et al*. 2014
Pruno spinosae-Rubion ulmifolii O. Bolòs 1954
Rubus ulmifolius community

QUERCO ROBORIS-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger 1937
Quercion pubescenti-petraeae Br.-Bl. 1932
Tilio pseudorubrae-Ostryion carpinifoliae S. Brullo *et al*. 2001
Quercus robur subsp. *brutia* community

References

Bartolucci F., Peruzzi L., Galasso G., Albano A., Alessandrini A., Ardenghi N.M.G., *et al*., 2018. An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179-303.

Bartolucci F., Domina G., Ardenghi N.M.G., Bacaro G., Bacchetta G., Ballarin F., *et al*., 2019. Notulae to the Italian native vascular flora: 8. Italian Botanist 8.

Beccarisi L., Ernandes P., Delle Rose M. & Zuccarello V., 2006. Valutazione dello stato di conservazione delle "spunnulate" della costa di Porto Cesareo e Nardò (provincia di Lecce) con un approccio vegetazionale. Thalassia Salentina 29(Suppl.): 215-236.

Beccarisi L., Medagli P., Mele C., Ernandes P. & Marchiori S., 2007. Precisazione sulla distribuzione di alcune specie rare degli ambienti umidi della Puglia meridionale (Italia). Italian Botanist 39(1): 87-98.

Bernardo L., Bartolucci F., Cancellieri L., Costalonga S., Galasso G., Galesi R., *et al*., 2012. Contribution to the floristic knowledge of the Presila Catanzarese: Report of the excursion of the "Gruppo di Floristica" (S.B.I.) held in 2008. Italian Botanist 44(1): 125-151.

Best E.P.H. & Van Der Werf A.K., 1986. Respiration in relation to reserve substances in the submerged macrophyte *Ceratophyllum demersum* L.. Aquatic Botany 26: 235-246.

Biondi E. & Blasi C. (Eds.), 2015. Prodromo della vegetazione italiana. Available online at http://www.prodromo-vegetazione-italia.org/ [Accessed on 26 Sep 2019]

Biondi E., Blasi C., Burrascano S., Casavecchia S., Copiz R., Del Vico E., *et al*., 2009. Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE. Società Botanica Italiana. Ministero dell'Ambiente e della tutela del territorio e del mare, D.P.N. Available online at http://vnr.unipg.it/habitat/ [Ac-

cessed on 26 Sep 2019]
Biondi E., 2011. Phytosociology today: Methodological and conceptual evolution. Plant Biosystems 145(Suppl.): 19-29.
Biondi E., Burrascano S., Casavecchia S., Copiz R., Del Vico E., Galdenzi D., *et al*., 2012. Diagnosis and syntaxonomic interpretation of Annex I Habitats (Dir. 92/43/ EEC) in Italy at the alliance level. Plant Sociology 49(1): 5-37.
Braun-Blanquet J., 1964. Pflanzensoziologie - Grundzüge der Vegetationskunde, 3. - Springer, Berlin, 865 p.
Brullo S., Guarino R., Minissale P., Siracusa G. & Spampinato G., 1999. Syntaxonomical analysis of the beech forests from Sicily. Annali di Botanica 57: 121-132.
Brullo S., Minissale P. & Spampinato G., 1994. Studio fitosociologico della vegetazione lacustre dei Monti Nebrodi (Sicilia settentrionale). Fitosociologia 27: 5-50.
Brullo S., Scelsi F. & Spampinato G., 2001. La Vegetazione dell'Aspromonte. Studio fitosociologico. Laruffa Editore, Reggio Calabria.
Brullo S. & Sciandrello S., 2006. La vegetazione del bacino lacustre "Biviere di Gela" (Sicilia meridionale). Fitosociologia 43(2): 21-40.
Brullo S. & Spampinato G., 1990. La vegetazione dei corsi d'acqua della Sicilia. Bollettino Accademia Gioenia Scienze Naturali 23(336): 119-252.
Brullo S. & Spampinato G., 1997. Indagine fitosociologica sulle ripisilve della Calabria (Italia meridionale). Lazaroa 18: 105-151.
Brullo S., Spampinato G., 1999. Syntaxonomy of hygrophilous woods of the *Alno-Quercion roboris*. Ann. Bot. Roma 57: 133-146.
Cameriere P., Crisafulli A., Maiorca G., Signorino G. & Spampinato G., 2008. Contributo alla conoscenza della vegetazione degli stagni temporanei della Calabria meridionale. Proceeding of the 103° Società Botanica Italiana Congress, Reggio Calabria, 17-19 settembre 2008: 236.
Cannavò S., Cesca G., Crisafulli A., Gangale C., Spampinato G. & Uzunov D., 2008. Il Lago dell'Aquila (Calabria meridionale), un biotopo da conservare. In: SBI, 103° Congresso della Società Botanica Italiana, Kalit Editrice. Reggio Calabria (ITA), Vol. 1, 2008, pp. 176.
Cano E., Cano-Ortiz A., Musarella C.M., Piñar Fuentes J.C., Ighbareyeh J.M.H., Leyva Gea F. & del Río S., 2019. Mitigating Climate Change through Bioclimatic Applications and Cultivation Techniques in Agriculture (Andalusia, Spain). In: Jhariya M., Banerjee A., Meena R., Yadav D. (eds) Sustainable Agriculture, Forest and Environmental Management. Springer, Singapore.
Cano E., Musarella C.M., Cano-Ortiz A., Piñar J.C., Pinto Gomes C.J., Rodríguez Torres A. & Spampinato G., 2017. A phytosociological review of siliceous sedges in C-W Spain and their state of conservation based on diversity indices. Plant Sociology 54(2) Suppl. 1: 5–14.
Cano-Ortiz A, Musarella C.M., Piñar J.C., Spampinato G., Veloz A. & Cano E., 2015a.Vegetation of the dry bioclimatic areas in the Dominican Republic. Plant Biosystems 149: 451-472.
Cano Ortiz A., Piñar Fuentes J.C., Pinto Gomes C.J., Musarella C.M. & Cano E., 2015b. Expansion of the *Juniperus* Genus due to Anthropic Activity. In Old-Growth Forests and Coniferous Forests: Ecology, Habitat and Conservation. Serie Environmental Research Advances. Ed. Ronal P. Weber: 55-65. New York.
Ceschin S., Abati S., Leacche I. & Zuccarello V., 2018. Ecological comparison between duckweeds in central Italy: The invasive *Lemna minuta* vs the native *L. minor*. Plant Biosystems 152 (4) 674-683.
Crisafulli A., Cannavò S., Maiorca G., Musarella C.M., Signorino G. & Spampinato G., 2010. Aggiornamenti floristici per la Calabria. Italian Botanist 42(2): 431-442.
De Leone D.A., 1783. Giornale e Notizie de' Tremuoti Accaduti l'Anno 1783 nella Provincia di Catanzaro. Ed. Stamperia F.lli Raimondi. Napoli.
Di Pietro R., Dibitonto P., Garziano G., Sciandrello S., Wagensommer R.P., Medagli P. & Tomaselli V., 2009. Preliminary results of floristic and vegetational surveys in three coastal humid areas in Puglia region (southern Italy). Lazaroa 30: 99-107.
Dudgeon D., Arthington A.H., Gessner M.O., Kawabata. Z, Knowler D.J. & Lévêque C., 2006. Freshwater biodiversity: Importance, threats, status and conservation challenges. Biological Reviews 81: 163–182.
Galanti G.M., 1792. Giornale di Viaggio in Calabria. (a cura di A. Placanica, 1981) Ed. SEN Napoli.
Galasso G., Conti F., Peruzzi L., Ardenghi N.M.G., Banfi E., Celesti-Grapow L., *et al*.., 2018. An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556-592.
Gigante D., Acosta A.T.R., Agrillo E., Armiraglio S., Assini S., Attorre F., *et al*., 2018. Habitat conservation in Italy: the state of the art in the light of the first European Red List of Terrestrial and Freshwater Habitats. Rendiconti lincei. Scienze fisiche e naturali 29(2): 251-265.
Gigante D., Attorre F., Venanzoni R., Acosta A., Agrillo E., Aleffi M., *et al*., 2016. A methodological protocol for Annex I Habitats monitoring: the contribution of Vegetation science. Plant Sociology 53(2): 77-87.
Giusso del Galdo G., Marcenò C., Musarella C.M. & Sciandrello S., 2008. La vegetazione costiera della R.N.O. "Torre Salsa" (Siculiana - AG). Italian Bota-

nist 40(1): 73-89.
Landucci F., Gigante D., Venanzoni R. & Chytrý M., 2013. Wetland vegetation of the class P*hragmito-Magno-Caricetea* in central Italy. Phytocoenologia 43: 67-100.
Lastrucci L., Bonari G., Angiolini C., Casini F., Giallonardo T., Gigante D., *et al*., 2014. Vegetation of Lakes Chiusi and Montepulciano (Siena, central Italy): updated knowledge and new discoveries. Plant Sociology 51: 29-55.
Lastrucci L., Dell'Olmo L., Foggi B., Massi L., Nuccio C., Vicenti C. & Viciani D., 2017 Contribution to the knowledge of the vegetation of the Lake Massaciuccoli (northern Tuscany, Italy). Plant Sociology 54(1): 67-87.
La Valva V. & Astolfi L. 1988. Secondo contributo alla conoscenza delle zone umide della Campania: la flora dei Variconi (Foce del Volturno - CE). Delpinoa 29-30: 77-106.
Lewis W.M. Jr., 1983. A revised classification of lakes based on mixing. Canadian Journal of Fisheries and Aquatic Sciences 40(10): 1779-1787.
Maiorca G., Spampinato G. & Caprio A., 2002. Flora e vegetazione dei laghi costieri La Vota (Calabria centro-occidentale). Fitosociologia 39(1): 81-108.
Maiorca G., Spampinato G., Crisafulli A. & Cameriere P., 2007. Flora vascolare e vegetazione della Riserva Naturale Regionale "Foce del Fiume Crati" (Calabria, Italia meridionale). Webbia 62(2): 121-174.
Medwet, 2018. Wetlands for a sustainable Mediterranean region. Available online at https://medwet.org/ [Accessed 26 Sep 2019]
Mendes P., Meireles C., Vila-Viçosa C., Musarella C.M. & Pinto-Gomes C., 2015. Best management practices to face degraded territories occupied by *Cistus ladanifer* shrublands – Portugal case study. Plant Biosystems 149(3): 494-502.
Minissale P. & Spampinato G., 1987. Osservazioni fitosociologiche sul Lago Gurrida (Sicilia Nord-orientale). Giornale Botanico Italiano 119(3-4): 197-225.
Musarella C.M., Laface V.L.A., Morabito A., Cano-Ortiz A., Cannavò S. & Spampinato G., 2019. Aggiornamenti sulla flora alloctona calabrese: novità e conferme. Notiziario della Società Botanica Italiana 3(1): 3.
Namura-Ochalska A., 2005. Contribution to the characteristic of *Cladium mariscus* (L.) Pohl population in the initial zone of floating mat on an oligo-humotrophic lake in north-eastern Poland. Acta Societatis Botanicorum Poloniae 74 (2): 167-173.
Passarge H., 1996. Pflanzengesellschaften Nordostdeutschlands. I. Hydro- und Therophytosa. Cramer, Stuttgart.
Pavone P., Spampinato G., Minissale P., Tomaselli V., Sciandrello S. & Ronsisvalle F., 2007. Cartografia degli habitat della Direttiva CEE 92/43 nei biotopi della Provincia di Siracusa (Sicilia orientale). Fitosociologia 44(2) supp.1: 183-193.
Petrucci O., 1997. Indagine storica sulle aree paludose. Conferenza "La malaria tra storia ed attualità". Cosenza.
Piñar Fuentes J.C., Cano-Ortiz A., Musarella C.M., Pinto Gomes C.J., Spampinato G. & Cano E., 2017. Rupicolous habitats of interest for conservation in the central-southern Iberian Peninsula. Plant Sociology 54(2) Suppl.1: 29-42.
Pott R., 2011. Phytosociology: A modern geobotanical method. Plant Biosystems 145(Suppl.): 9-18.
Quinto-Canas R., Mendes P., Cano-Ortiz A., Musarella C.M. & Pinto-Gomes C., 2018a. Forest fringe communities of the southwestern Iberian Peninsula. Revista Chapingo Serie Ciencias Forestales y del Ambiente 24(3): 415-434.
Quinto-Canas R., Mendes P., Cano-Ortiz A., Musarella C.M. & Pinto-Gomes C., 2018b. The *Agrostion castellanae* Rivas Goday 1957 corr. Rivas Goday & Rivas-Martínez 1963 alliance in the southwestern Iberian Peninsula. Plant Sociology 55: 21–29.
Rivas-Martínez S., 1996-2019. Global Bioclimatics (Clasificación Bioclimática de la Tierra) Nueva Versión de 01-12-2008. Available online at www.globalbioclimatics.org/book/bioc/global_bioclimatics-2008_00.htm [Accessed on 26 Sep 2019]
Rodwell, J.S., (Ed.). 1995. British Plant Communities. 4: Aquatic communities, swamps and tall-herb fens. Cambridge University Press.
Russo E., Ruello M.R., Cicala L., Di Lorenzo H., Molisso F. & Pacciarelli M., 2018. An 8300-yr record of environmental and cultural changes in the Sant' Eufemia Plain (Calabria, Italy). Quat. Int. 483: 39-56.
Sburlino G., Tomasella M., Oriolo G. & Poldini L., 2004. La vegetazione acquatica e palustre dell'Italia nord-orientale. 1 - La classe *Lemnetea* Tűxen ex O. Bolos et Masclans 1955. Fitosociologia 41(1) suppl. 1: 27-42.
Sciandrello S., Guglielmo A. & Spampinato G., 2014. Spatial patterns and floristic composition of plant communities in coastal salt marshes of south-eastern Sicily (Italy). Acta Botanica Gallica 161(2): 99-109.
Sciandrello S. & Tomaselli V., 2014. Coastal salt marshes plant communities of the Salicornietea fruticosae class in Apulia (Italy). Biologia 69/1: 53-69.
Spampinato G., Crisafulli A. & Cameriere P., 2007. Trasformazione delle zone costiere della Regione Calabria (Italia meridionale) e conseguenze sulla flora degli ambienti umidi. Fitosociologia 44(2): 119-128.
Spampinato G., Crisarà R., Cannavò S. & Musarella C.M., 2017. Phytotoponims of southern Calabria: A tool for the analysis of the landscape and its transformations. Atti Società Toscana Scienze Naturali Memorie Serie B 124: 61-72.

Spampinato G., Musarella C.M., Cano-Ortiz A. & Signorino G., 2018. Habitat, occurrence and conservation status of the Saharo-Macaronesian and Southern-Mediterranean element *Fagonia cretica* L. (*Zygophyllaceae*) in Italy. Journal of Arid Land 10(1): 140–151.

Strumia S., 2004. Contributo alla conoscenza delle cenosi forestali ripariali del fiume Volturno (Campania). Delpinoa n.s. 46: 63-70.

Šumberová K., 2011. Vegetace vodních rostlin zakořeněných ve dně (*Potametea*). Vegetation of aquatic plants rooted in the bottom. In Chytrý M. (Ed.), Vegetace České republiky 3. Vodní a mokřadní vegetace. [Vegetation of the Czech Republic 3. Aquatic and wetland vegetation]: 100-247. Academia, Praha.

Tomaselli V. & Sciandrello S., 2017. Contribution to the knowledge of the coastal vegetation of the Zone Umide della Capitanata (Apulia, Italy). Plant Biosystems 151(4): 673-694.

Tomaselli V., Di Pietro R. & Sciandrello S., 2011. Plant communities structure and composition in three coastal wetlands in southern Apulia (Italy). Biologia 66(6): 1027-1043.

Van der Maarel E., 1979. Transformation of cover-abundance values in phytosociology and its effects on community similarity. Vegetatio 39: 97-114.

Venanzoni R., Properzi A., Bricchi E., Landucci F. & Gigante D., 2018. The *Magnocaricetalia* Pignatti 1953 (*Phragmito-Magnocaricetea* Klika in Klika et Novák 1941) Plant Communities of Italy. In: Pedrotti F. (Ed.). Climate Gradients and Biodiversity in Mountains of Italy. GEOBOTANY STUDIES, vol. Climate Gradients and Biodiversity in Mountains of Italy: 135-173. Springer International Publishing AG.

Veronico G., Sciandrello S., Medagli P. & Tomaselli V., 2017. Vegetation survey and plant landscape mapping of the SCI IT9140002 "Litorale Brindisino" (Puglia, Southern Italy). Plant Sociology 54(1): 89-106.

Vila-Viçosa C., Vázquez F., Mendes P., del Rio S., Musarella C.M., Cano-Ortiz A. & Meireles C., 2015. Syntaxonomic update on the relict groves of Mirbeck's oak (*Quercus canariensis* Willd. and *Q. marianica* C. Vicioso) in southern Iberia. Plant Biosystems 149(3): 512-526.

WetVegEurope, 2018. European marsh vegetation: synthesis and formalized classification for nature conservation. Available online at http://www.sci.muni.cz/botany/vegsci/wetveg/ [Accessed on 26 Sep 2019].

Zivkovic L., Biondi E., Pesaresi S., Lasen C., Spampinato G. & Angelini P., 2017. The third report on the conservation status of habitats (Directive 92/43/EEC) in Italy: processes, methodologies, results and comments. Plant Sociology 54(2): 51-64.