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Natura 2000 protected habitats, Massaciuccoli Lake (northern Tuscany, Italy)

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ABSTRACT

The Massaciuccoli Lake (northern Tuscany, Italy) Natura 2000 habitat map (1:10,000) was compiled from photo-interpretation and recent phytosociological studies, integrated by field surveys of the vegetation units. Conventional geographical information system procedures were used to select and manage spatial information. The following attributes were assigned to each map polygon: (i) vegetation type, (ii) habitat typology and (iii) percentage cover of the habitat type. Habitat types covering polygons smaller than 50 m² were treated as points. A total of nine Natura 2000 habitat types were identified and mapped; they cover almost 20% of the study area. The results show that of all sites on the Italian peninsula, Lake Massaciuccoli Calcareous fens with *Cladium mariscus* covers the largest surface area and is crucial for the national conservation of this habitat type. It is also of priority importance in Europe.

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1. Introduction



Habitats, in the pragmatic definition given in European Directives (Commission of the European Community, 1992; European Commission, 2013; Evans, 2006, 2010), are considered to be a cornerstone of European nature conservation policy, because the maintenance of a series of habitats in good condition is one of the best ways to conserve species and biodiversity (Berg et al., 2014; Bunce et al., 2013; Evans, 2012; Gigante, Foggi, Venanzoni, Viciani, & Buffa, 2016; Kontula & Raunio, 2009; Nicholson, Keith, & Wilcove, 2009; Rodríguez et al., 2011, 2012, 2015).

According to European Directive 92/43/EEC, the field identification of a habitat is based on matching it to one (or more) vegetation types (Angiolini, Viciani, Bonari, & Lastrucci, 2016; Biondi, Casavecchia, & Pesaresi, 2010, 2012; Bunce et al., 2013; European Commission, 2013; Evans, 2006; Keith et al., 2013, 2015; Rodwell et al., 2002; Viciani, Lastrucci, Dell'Olmo, Ferretti, & Foggi, 2014). For this reason, several national and regional vegetation mapping and vegetation data archiving projects are currently being carried out (e.g. Bonis & Bouzillé, 2012; Dimopoulos et al., 2012; Font, Pérez-García, Biurrun, Fernández-González, & Lence, 2012). In Italy, a similar project named 'VegItaly' is underway (Gigante et al., 2012; Landucci et al., 2012) but is far from completion in many regions. Tuscany is one of the regions in which work is ongoing (Viciani et al., 2014). The Tuscan Regional Administration has commenced a comprehensive vegetation mapping

project for its Natura 2000 Sites of Community Importance (SCI), the areas that can reasonably be considered an essential framework for active *in situ* conservation (Foggi et al., 2015). Accurate habitat mapping is an important tool in conservation (Asensi & Díaz-Garretas, 2007; Biondi et al., 2007; Loidi, Ortega, & Orrantia, 2007; Pavone et al., 2007; Viciani, Dell'Olmo, et al., 2016) and especially in areas considered hotspots of biodiversity, such as the Mediterranean basin (Médail & Quézel, 1999; Myers, Mittermeier, & Mittermeier, 2000) and/or in wetland areas (Bedford, Leopold, & Gibbs, 2001; Brinson & Malvárez, 2002; Dudgeon et al., 2006; Underwood, Viers, Klausmeyer, Cox, & Shaw, 2009). The aim of this study was to develop a habitat map for the Massaciuccoli Lake, a Tuscan protected area and one of the most important wetlands of the Italian peninsula, in the central-northern Mediterranean basin.

2. Study area

Lake Massaciuccoli is located in north-western Tuscany, mainly in Lucca Province and partly in Pisa Province (Figure 1). It has a surface area of 1908 ha and an altitude of 0–1 m a.s.l. The lake is one of the most important Tuscan Ramsar wetlands (MedWet Inventory site code: ITE12W0400; see D'Antoni, Battisti, Cenni, & Rossi, 2011). The lake and the surrounding areas are included in the Tuscan regional park 'Migliarino-San Rossore-Massaciuccoli' and are part

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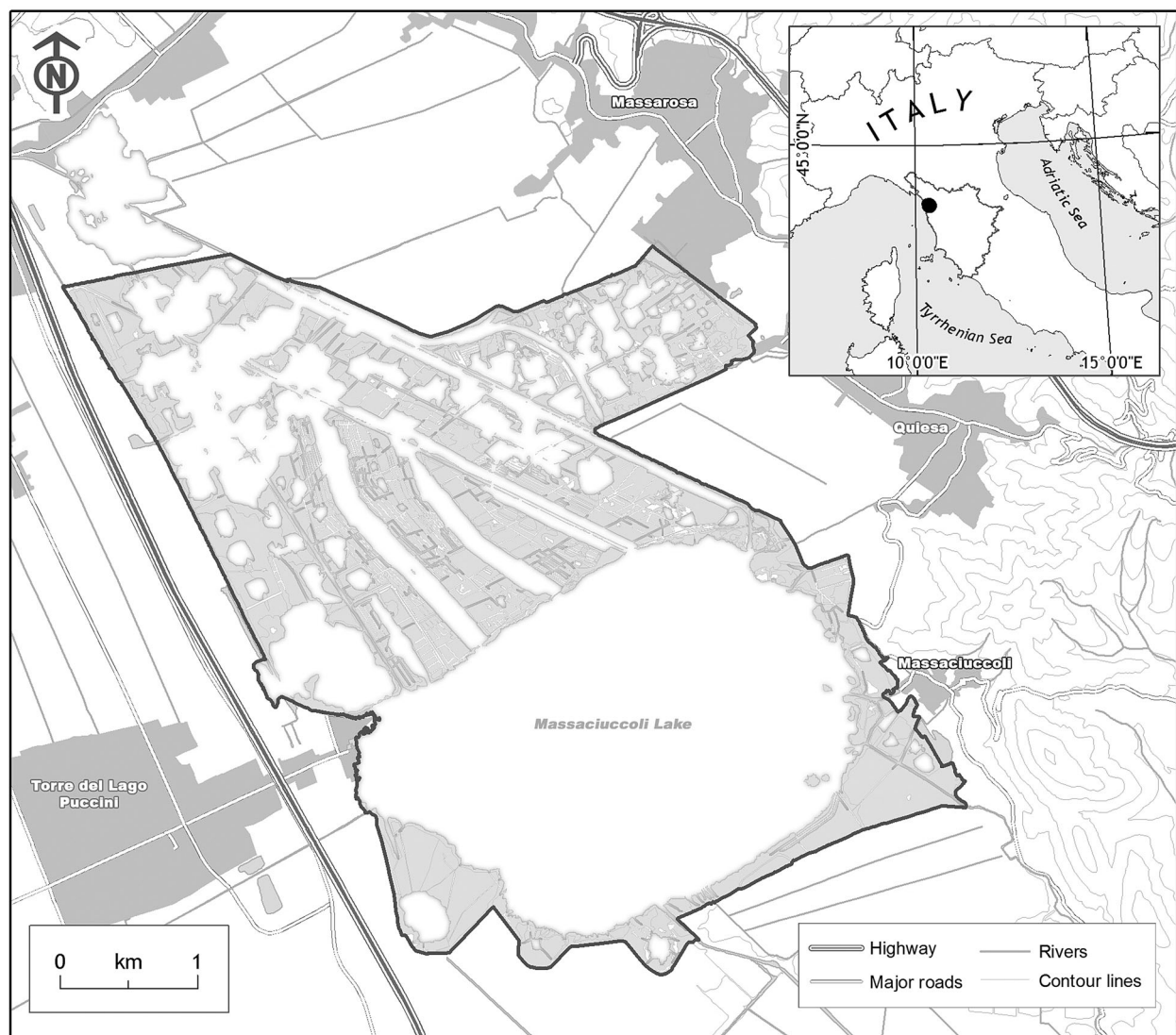


Figure 1. Location of the study area.

of the Natura 2000 network as a SCI, named ‘Lago e Padule di Massaciuccoli’, recently approved as a Special Area of Conservation. It was included in the updated list of SCIs for the Mediterranean biogeographical region in Italy (code IT5120017), according to Dir. 92/43/EEC, Annex A. This area is also listed as an Important Bird Area (IBA 077) according to Bird-Life International (Brunner, Celada, Gustin, & Rossi, 2002).

Following the climatic classification of Thornthwaite and Mather (1957), Rapetti, Tomei, and Vittorini (1987) calculated that the climate formula for Massaciuccoli is C2 B2' r b4' (a sub-humid climate, with reduced summer deficit and considerable maritime character). According to the worldwide bioclimatic classification system of Rivas-Martínez, the study area is included in a Mediterranean Pluviseasonal oceanic bioclimate, but close to the border with a Temperate Oceanic (Submediterranean) bioclimate (Pesaresi, Galdenzi, Biondi, & Casavecchia, 2014).

The basin of Lake Massaciuccoli is formed by a sandy coastal area and an inner part consisting of

peat swamps, often reclaimed and cultivated (Menozzi et al., 2002). The upper sediments belong mostly to the Holocene and consist of alternating layers of marine, lagoonal, lacustrine and palustrine deposits (Carmignani & Lazzarotto, 2004; Menozzi et al., 2002).

The plant landscape is characterized by typical fresh water vegetation types, dominated by helophytes on shores and marshes (reeds, sedges, cattails and rushes) and by hydrophytes in the water bodies (Lastrucci et al., 2017). In addition to its importance for birds, the study area has great botanical importance for the conservation of rare and relict plant species, so it has been the subject of extensive botanical exploration (for updated references to the botanical literature see Lastrucci et al., 2017).

3. Methods

All cartographic and phytosociological information available for the study area was interpreted on the basis of our field knowledge. The main source was Lastrucci et al. (2017), but we included studies on

Table 1. Natura 2000 habitat types for the Site of Community Importance (SCI) Lake Massaciuccoli, with surface areas (ha) and cover percentages, with respect to the total area covered by Natura 2000 habitats.

Natura 2000 habitat code	Natura 2000 habitat name	Polygon area (ha)	Actual area covered (ha)	%
3130	Oligotrophic to mesotrophic standing waters with vegetation of the <i>Littorelletea uniflorae</i> and/or of the <i>Isoëto-Nanojuncetea</i>	<0.005	<0.005	<0.001
3150	Natural eutrophic lakes with <i>Magnopotamion</i> or <i>Hydrocharition</i> -type vegetation	3.30	2.35	0.90
3270	Rivers with muddy banks with <i>Chenopodion rubri</i> p.p. and <i>Bidention</i> p.p. vegetation	<0.005	<0.005	<0.001
3280	Constantly flowing Mediterranean rivers with <i>Paspalo-Agrostidion</i> species and hanging curtains of <i>Salix</i> and <i>Populus alba</i>	<0.005	<0.005	<0.001
6420	Mediterranean tall humid herb grasslands of the <i>Molinio-Holoschoenion</i>	<0.005	<0.005	<0.001
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	<0.005	<0.005	<0.001
7140	Transition mires and quaking bogs	0.33	0.29	0.11
7210 ^a	Calcareous fens with <i>Cladium mariscus</i> and species of the <i>Caricion davallianae</i>	371.70	256.68	97.82
91E0 ^a	Alluvial forests with <i>Alnus glutinosa</i> and <i>Fraxinus excelsior</i> (<i>Alno-Padion</i> , <i>Alnion incanae</i> , <i>Salicion albae</i>)	3.06	3.06	1.17
Natura 2000 habitat total cover area		378.40	262.40	100.00
SCI Lake Massaciuccoli total cover area		1905.57	–	100.00
Natura 2000 habitat cover with respect to Lake Massaciuccoli total area		378.40	–	19.86
Other habitat types not listed in the Habitat Directive 92/43/EEC (mainly <i>Phragmites australis</i> communities)		255.79	–	13.42
Lake, canals		1271.37	–	66.72

^aPriority habitat.

vegetation series by Blasi (2010a, 2010b), Viciani, Lastrucci, Geri, and Foggi (2016) and previous vegetation maps and vegetation studies (Ferrarini, 1972; Montelucci, 1964; Petraglia, 2013; Tomei & Garbari, 1982; Tomei, Barsanti, & Guazzi, 1994, 1997, 1998, 2001).

The vegetation survey of the study area by Lastrucci et al. (2017) was carried out during the period 2015–2016, adopting the phytosociological method (Biondi, 2011; Braun-Blanquet, 1964). Over 90 phytosociological relevés were surveyed and analysed across the whole area, leading to the identification of several vegetation types of various syntaxonomical ranks (see Lastrucci et al., 2017). Over the same period, many field surveys aimed at the recognition of the habitats of conservation interest were carried out. We used the Tuscany Region aerial georeferenced orthophotos, true colour RGB, acquired in June and July 2013, with a resolution of 50 × 50 cm. The interpretation of orthophotos, according to the ‘Photo Guided Method’ (Küchler & Zonneveld, 1988; Zonneveld, 1979) together with the study of the spatial distribution of land use and vegetation types (recognized in the field on both physiognomic and phytosociological bases) allowed identification of land use and vegetation types at a scale of 1:3000 to 1:5000. In order to delimit the different polygons, we considered many factors: (i) results of the vegetation relevés, that provided georeferenced locations of the floristic composition of the local plant community; (ii) analysis of orthophotos (colours, tones, textures and grain) around the relevé point that, together with the local hydrology, soil water management and geolithology characteristics, helped us to define the borders between different typologies. Moreover, we made much field work during different seasons to check the attributions and limits of landscape units. In some difficult cases, where the transition between two community/habitat types was found to

be gradual, the limits assigned and surface areas calculated were subjected to change. Using this information, a lake vegetation map (1:10,000) was compiled and be used to derive the habitat map.

Information used to interpret the habitat types was derived from European Community documents and from the literature (Angelini, Bianco, Cardillo, Francescato, & Oriolo, 2009, 2016; Biondi & Blasi, 2009, 2016; Biondi et al., 2010, 2012; Commission of the European Community, 1991, 1992; European Commission, 2013; Evans, 2006, 2010). The map of conservation-interest habitats (*sensu* 92/43 EC Directive, Natura 2000) was created using a geographical information system (GIS).

To extract and select the information used, conventional GIS queries were employed. The following attributes were assigned to each map polygon: (i) vegetation type according to Lastrucci et al. (2017), (ii) habitat typology, with Natura 2000 code and (iii) percentage cover occupied by the habitat type. A habitat type could occupy the whole polygon area or could occur within a polygon together with other habitats not of conservation interest. In the latter cases, the percentage cover of the Natura 2000 habitat types were estimated on the basis of professional and scientific experience acquired while conducting the field surveys. In particular, for the most widespread habitat type (Calcareous fens with *Cladium mariscus*, code 7210), we estimated from aerial photos and field work four possible habitat conditions: (i) habitat in optimal conditions, with *Cladium* cover close to 100%; (ii) habitat in suboptimal conditions, with *Cladium* cover around 75%; (iii) habitat in medium conditions, with *Cladium* cover around 50% and (iv) habitat fragmented, with *Cladium* cover around 25%. The minimum mapping unit was assumed to be 50 m². Habitat types covering polygons smaller than 50 m² were treated as points.

In the text, plant names are indicated without authors for brevity. The references for the complete nomenclature are Conti, Abbate, Alessandrini, and Blasi (2005) and the ‘anArchive’ database (Lucarini, Gigante, Landucci, Panfili, & Venanzoni, 2015).

4. Results and discussion

The Natura 2000 habitat map was released at 1:10,000 (Main Map). A total of nine conservation interest habitat types were identified (Table 1), all related to aquatic, hygrophilous or marshy environments. Five habitat types had areas below the minimum mapping unit of 50 m² and were marked on the maps as points (see Main Map).

The Natura 2000 habitats cover almost 20% of the total area of the Lake Massaciuccoli site and have a total area of about 262 ha. Two priority European interest habitats, that is, habitat types particularly deserving conservation, listed in Annex I of the Habitat Directive (Calcareous fens with *C. mariscus* and alluvial forests with *Alnus glutinosa*, codes 7210 and 91E0, respectively) cover about 99% (Table 1). In particular, Lake Massaciuccoli is crucial for the conservation of *C. mariscus*-dominated communities of the Italian peninsula. This habitat type is not common in Mediterranean Europe (Landucci, Gigante, Venanzoni, & Chytrý, 2013; Lastrucci et al., 2017; Venanzoni & Gigante, 2000), and the study area, at more than 250 ha, has the largest surface area of this habitat type on the Italian peninsula (MATTM, 2016). In Lake Massaciuccoli, *C. mariscus* stands are in contact with *Phragmites australis* communities, not listed as a habitat of conservation importance in the 92/43 EC Directive; in some areas, *P. australis* tends to form mixed coenoses with *Cladium*, and even becomes dominant (Lastrucci et al., 2017; Tomei et al., 1994). According to Mariotti (2009), water eutrophication (i.e. the abundance of plant nutrients, nitrates and phosphates) can favour *P. australis* to the detriment of *C. mariscus*, and increasing eutrophication is a problem reported for Lake Massaciuccoli (Ente Parco Regionale Migliarino San Rossore Massaciuccoli, 2013; Lastrucci et al., 2017). An eventual expansion of the reed can thus locally transform some *Cladium*-dominated areas in *Phragmites*-dominated communities, leading to deterioration, fragmentation or even disappearance of the habitat. This process has already been reported for the study area and could have been facilitated by the abandonment of human management of *C. mariscus* communities for craft purposes (Lastrucci et al., 2017; Tomei et al., 1994). The differentiation of Habitat 7210 in the four cartographical typologies we adopted can be useful for determining the local ‘health status’ of this important habitat at the map date. Simplifying, we can say that when *Cladium* covers 100% or 75%, the habitat is in optimal or suboptimal condition, when

Cladium covers around 50%, the habitat is in medium condition and the population interactions with *Phragmites* should be monitored, when *Cladium* covers only 25%, the habitat is fragmented and deteriorated. In this case, it should be monitored and, if possible, insights into the problem and actions for habitat restoration should be planned.

The point habitats present in the map (Natura 2000 codes 3130, 3270, 3280, 6420, 6430) are worthy of note, but are not of particular relevance for Lake Massaciuccoli, as many of them are widespread in Mediterranean wetlands and partly formed of alien plants (Angelini, Casella, Grignetti, & Genovesi, 2016; Biondi & Blasi, 2009), even if a general lack of information for these habitat types has been highlighted (Genovesi et al., 2014).

The Habitat Natura 2000 Code 3150 (eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation) includes almost all the aquatic plant communities recorded in the study area. Even if it does not cover large surfaces, it is relevant because it is one of the habitat types that has experienced a great reduction in recent decades, particularly due to the increasing spread of invasive alien animal species (*Myocastor coypus*, *Procambarus clarkii*) that feed on and destroy plants typical of this habitat, both globally (Carter & Leonard, 2002; Gherardi, 2007) and locally (Bertolino, Perrone, & Gola, 2005; Tomei et al., 1994).

The other habitat type of priority interest is Natura 2000 Code 91E0 (Alluvial forests with *A. glutinosa*). Black alder formations are fragmented and reduced in comparison to the past (Pedrotti & Gafta, 1996) and subject to several threats and pressures such as alteration of the hydrologic regime, water eutrophication, agriculture, etc. (Angelini et al., 2016). However, they are not rare and are present in southern Europe and in the Italian peninsula mostly as riparian forests along rivers and water courses (Pedrotti & Gafta, 1996). In the study area, we recorded small and fragmented patches of marshy woods, not common in the Mediterranean basin, also rich in plants of conservation and/or phytogeographical interest, such as *Osmunda regalis*, *Hydrocotyle vulgaris*, *Periploca graeca*, *Thelypteris palustris* and *Sphagnum spp.*; these particular alder communities have a limited distribution at the national level and can be considered rare, as noted by Sburlino, Poldini, Venanzoni, and Ghirelli (2011).

In the study area, a rare and interesting vegetation type consists of *Sphagnum* (*S. palustre* and *S. subnitens*) dense carpets, that can be attributed (according to Petraglia (2013) and Lastrucci et al. (2017)) to the Habitat Natura 2000 code 7140 (transition mires and quaking bogs), a habitat type very rare in southern Europe and the Mediterranean basin, especially in lowlands, where mires and bogs are a true relict (Biondi & Blasi, 2009). In the study area, this habitat type is favoured by the management

of *P. australis* communities, consisting in the cutting and removal of reed litter (Petraglia, 2013). The *Sphagnum* carpets were found in small patches, within reedbeds developing on floating islands, rich in decaying organic matter (syntaxonomically belonging to the association *Thelypterido palustris-Phragmitetum australis*). These rare communities, though not listed as a habitat of conservation importance in European Directive 92/43/EEC, were recognized to have a great conservation interest (Angiolini et al., 2016; Lastrucci et al., 2014, 2017).

5. Conclusions

The production of an accurate Natura 2000 habitat map involves a number of activities from several perspectives (e.g. a large amount of field work and photo-interpretation, plant identification, syntaxonomical classification of vegetation, etc.), but is crucial to the designation of Sites of Community Interest by the Member States as stated in the Habitats Directive (Commission of the European Community, 1992). Furthermore, where there is an obligation on behalf of the Member State to guarantee a Favourable Conservation Status, with requirements for monitoring and reporting, at least for the habitats for which the SCI has been designated (Commission of the European Community, 1992; Evans & Arvela, 2011; Osterman, 1998), Natura 2000 habitat maps represent an extremely valuable tool for gaining new or updated knowledge and for monitoring of habitats in the Natura 2000 network sites. This is particularly true now, as the attention of conservationists is increasingly being focused on evaluating not only species but also communities (e.g. habitats, biotopes, ecosystems, ecological communities: see Berg et al., 2014; Gigante, Buffa, Foggi, Venanzoni, & Viciani, 2013; Izco, 2015; Keith et al., 2013, 2015; Kontula & Raunio, 2009; Nicholson et al., 2009; Rodríguez et al., 2011, 2012). A methodological framework for monitoring conservation interest habitats in the Natura 2000 network is under construction, at the European (Evans & Arvela, 2011; Rodwell, Janssen, Gubbay, & Schaminée, 2013) and Italian level (Angelini et al., 2016; Gigante, Attorre, et al., 2016).

Software

The maps were created and edited using *Esri ArcGIS 10.4*.

Disclosure statement

No potential conflict of interest was reported by the authors.

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