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Natura 2000 habitat of Mt. Argentario promontory (southern Tuscany, Italy)

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ABSTRACT

The Mt. Argentario promontory (southern Tuscany, Italy) is a protected area hosting habitats and species of European importance. The Mt. Argentario Natura 2000 habitat map (1:10,000) was compiled from photo-interpretation and field surveys, integrated with data from past cartographic and phytosociological studies. Conventional geographical information system procedures were used to select and manage spatial information, and delimit the map polygons. The following attributes were assigned to each map polygon: (i) habitat type name, with Natura 2000 code and (ii) percentage cover of the habitat type. Where multiple habitat types were associated in a mosaic attributed to the same polygon, the percentage cover of each habitat type was estimated. The survey allowed to identify and map a total of 13 Natura 2000 habitat types covering more than 40% of the study area. Presence and conservation importance of the detected habitat types are discussed, together with the usefulness of this kind of maps for monitoring and managing purposes.

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1. Introduction

The conservation of biodiversity, at all its multiple levels of organization, is universally considered a crucial goal (Balmford et al., 2002; Cafaro & Primack, 2014; Millennium Ecosystem Assessment, 2005), as shown by the numerous existing national and international agreements, frameworks and directives focused to stop and prevent biodiversity loss (see e.g. CITES, 1973; Commission of the European Community, 1992; European Commission, 2011; Secretariat of the Convention on Biological Diversity, 2010; United Nations, 1976, 1992, 2015). In the past, conservation was mainly focused on the species level (IUCN, 2012, 2013; Mace et al., 2008), but in recent times it became increasingly evident that biodiversity can be more effectively represented, monitored and preserved by an 'above species level approach', because this may more efficiently represent the biological diversity as a whole and also indirectly preserve those species not yet or poorly known (Berg et al., 2014; Cowling et al., 2004; Galdenzi, Pesaresi, Casavecchia, Zivkovic, & Biond, 2012; Gigante, Attorre, et al., 2016; Izco, 2015; Keith et al., 2015; Kontula & Raunio, 2009; Nicholson, Keith, & Wilcove, 2009; Noss, 1996; Rodríguez et al., 2011, 2012, 2015; Viciani, Lastrucci, Dell'Olmo, Ferretti, & Foggi, 2014). This 'above species level unit' can be an ecosystem, an ecological community or other similarly defined operational units (IUCN, 2015; Nicholson et al., 2009). Habitats, in the pragmatic

definition given in the European Directives (Commission of the European Community, 1992; European Commission, 2013; Evans, 2006, 2010), are considered a suitable 'above species level' operational unit and have become a central pillar 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 et al., 2009; Rodríguez et al., 2011, 2012, 2015). This approach led also to the production of the first European Red List of Habitats (Janssen et al., 2016).

According to the 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, 2017; Biondi, Casavecchia, & Pesaresi, 2010; Biondi et al., 2012; Bunce et al., 2013; European Commission, 2013; Evans, 2006; Keith et al., 2013, 2015; Rodwell et al., 2002; Viciani et al., 2014; Viciani, Dell'Olmo, et al., 2016; Viciani, Dell'Olmo, Vicenti, & Lastrucci, 2017). 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; Gigante et al., 2012; Landucci et al., 2012). Tuscany is one of the regions in which

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work is ongoing (Viciani, Lastrucci, et al., 2014; Viciani, Dell'Olmo, et al., 2016, 2017). The Tuscan Regional Administration and the University of Florence have just finished a comprehensive habitat mapping project (named HaSCITu) involving the mapping of conservation-relevant habitats in its Natura 2000 Sites of Community Importance (SCI, all confirmed now as Special Areas of Conservation – SACs), the protected areas that can reasonably be considered an essential framework for active *in situ* conservation (Commission of the European Community, 1992; Foggi, Viciani, Baldini, Carta, & Guidi, 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), especially in areas considered hot-spots of biodiversity, such as the Mediterranean basin (Casazza et al., 2014; Médail & Quézel, 1999; Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000). The aim of this study was to develop a Natura 2000 habitat map for Mt. Argentario, a Tuscan coastal promontory that was in the past one of the islands of the Tuscan Archipelago (central-northern Mediterranean basin), and today is a Special Area of Conservation, i.e. an important protected area of the Italian peninsula belonging to Natura 2000 network.

2. The study area

Mt. Argentario is an orographically isolated promontory located in the south-western Tuscan coast (Figure 1), in the Mediterranean Biogeographic region (European Environment Agency, 2017). It is considered a 'fossil island', belonging in the past to the Tuscan Archipelago, because only in relatively recent times it was connected to the mainland by sand deposits, which formed two cordons of dunes and an internal lagoon (Arrigoni & Di Tommaso, 1997; Lanza, 1984; Lazzarotto, Mazzanti, & Mazzoncini, 1964). It has an area of about 60 km² and a coastline formed mainly by steep rocky cliffs, alternate with small stony and sometimes sandy inlets. Mt. Argentario has a varied orography, with Punta Telegrafo (635 m a.s.l.) being the highest point. It has a complex geology and geomorphology, with limestones and dolostones, metasandstones and acid metavolcanic rocks, calcschists and metamorphic ophiolites (Carmignani & Lazzarotto, 2004). The climate is typically Mediterranean, with a mild winter and a warm and arid summer (Arrigoni & Di Tommaso, 1997). The promontory as a whole is part of the Mediterranean macrobioclimate, pluviseasonal-oceanic bioclimate, with a lower mesomediterranean thermotype at lower altitudes and an upper mesomediterranean thermotype at higher altitudes (Pesaresi, Biondi, & Casavecchia, 2017).

The landscape is dominated by a typical Mediterranean sclerophyllous – evergreen forest and by its

degradation stages, such as high and low matorrals, garrigues and discontinuous ephemeral grasslands (Arrigoni & Di Tommaso, 1997). The vegetation has been heavily disturbed for millennia by anthropic recurrent fires, clearance for agricultural purposes, grazing and, in recent years, also by reforestation. As a consequence, the present vegetation is a mosaic of plant communities at different successional stages, influenced by the past land uses and by some natural local factors, such as different substrata, altitude, exposure, geomorphological features, distance from the sea, etc. (Arrigoni & Di Tommaso, 1997).

A large part of the promontory surface (the main urban areas are excluded) is part of the Special Area of Conservation named 'Monte Argentario, Isolotto di Porto Ercole e Argentarola', a protected area of European importance (SAC code: IT51A0025 – Habitats Directive 92/43/EEC).

3. Methods

All the cartographic and phytosociological information available for Mt. Argentario was interpreted on the basis of our field knowledge. The main sources were Cavalli (1985), Arrigoni and Di Tommaso (1997), Arrigoni et al. (2001), but we also included studies on vegetation series by Blasi (2010a, 2010b), Viciani, Lastrucci, Geri, and Foggi (2016) and previous vegetation studies and habitat maps concerning, in particular, the islands of the Tuscan Archipelago, because of their similarity with the study area (Biondi, Vagge, & Mossa, 2000; Foggi et al., 2006, 2011; Foggi & Grigioni, 1999; Foggi & Pancioli, 2008; Foggi, Cartei, & Pignotti, 2008; Viciani, Albanesi, Dell'Olmo, & Foggi, 2011; Viciani, Dell'Olmo, et al., 2016). Data sources and correspondence between the available vegetation information and the mapped Natura 2000 habitat types are reported in Table S1.

The main vegetation survey regarding Mt. Argentario, by Arrigoni and Di Tommaso (1997), was carried out adopting the phytosociological method (Biondi, 2011; Braun-Blanquet, 1964) and consisted of over 110 phytosociological relevés that were surveyed and analysed across the whole territory, leading to the identification of several vegetation types of various syn-taxonomical ranks (see Arrigoni & Di Tommaso, 1997). To update this information, we considered also a more recent and unpublished cartographic environmental study, with land use and phytosociological data, promoted by the Municipality of Mt. Argentario, but the main sources for the habitat map were field work and photo-interpretation.

In the period 2014–2016 many field surveys were carried out, with the aim of identifying the habitats of conservation interest. For photo-interpretation, we used the Tuscany Region aerial georeferenced

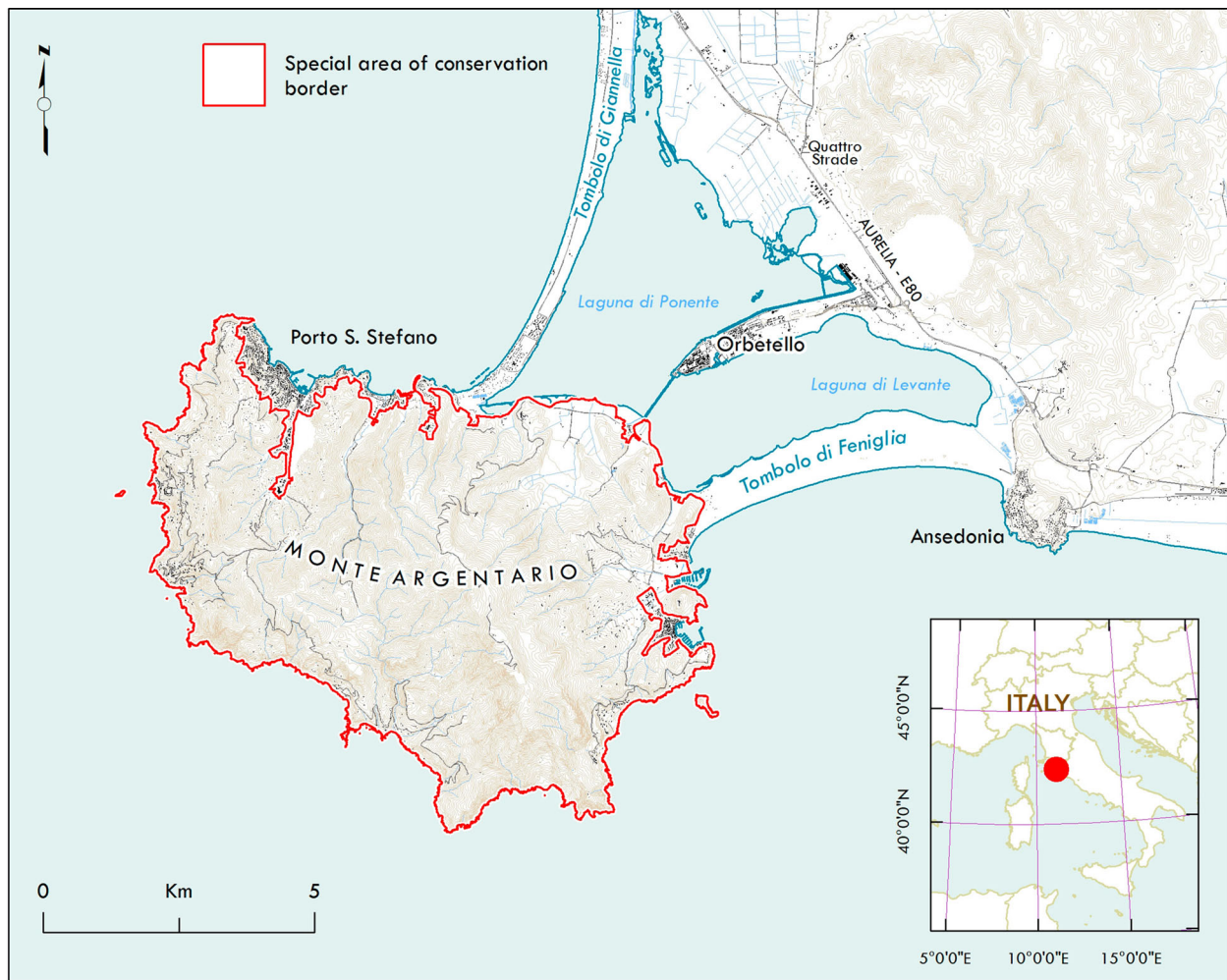


Figure 1. Location of the study area.

orthophotos, true colour RGB, acquired in June and July 2013, with an on-the-ground pixel resolution of 50×50 cm, with accuracy guaranteed by the Tuscan Regional WMS Service. 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 between 1:5000 and 1:10,000. In order to delimit the different polygons, through manual segmentation, we considered many factors: (i) the results of the field surveys that, together with the vegetation relevé data, provided georeferenced locations of the floristic composition of the local plant communities; (ii) the analysis of the orthophoto traits (colors, tones, textures and grain) around the relevé point that, together with the local geomorphological and lithological characteristics, helped us to define the borders between different typologies. Of course, in some difficult cases, when the transition between two community/habitat types were found to be gradual, the limits we assigned and the surface areas we calculated could be subjected to some changes. Using this

information, a vegetation map (1:10,000) was compiled and 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; Angelini, Casella, Grignetti, & Genovesi, 2016; Biondi et al., 2010, 2012; Biondi & Blasi, 2009, 2016; 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 GIS software.

To extract and select the information used, conventional GIS queries were employed. The following attributes were assigned to each map polygon: (i) habitat typology, with Natura 2000 code; (ii) percentage cover occupied by each habitat type. Where more than one habitat type co-occurred within the same polygon without being possible to separate them (very small and/or very fragmented units), we used the 'mosaic' concept. In such cases, the relative percentage cover of the habitat types forming the mosaic were estimated on the basis of professional and scientific experience acquired while conducting the field surveys. The equivalent area occupied by each habitat type was

Table 1. Natura 2000 habitat types of the Mt. Argentario Special Area of Conservation (SAC), with surface areas (ha) and cover percentages, with respect to the total area of the SAC and to the overall area covered by Natura 2000 habitats.

Natura 2000 habitat code (* = priority habitat)	Natura 2000 habitat name	Area (ha)	% cover of total SAC area	% cover of overall Natura 2000 habitat area in SAC
1240	Vegetated sea cliffs of the Mediterranean coasts with endemic <i>Limonium</i> spp.	64,85	1,13	2,78
1310	Salicornia and other annuals colonizing mud and sand	0,10	0,00	0,00
1410	Mediterranean salt meadows (<i>Juncetalia maritimi</i>)	0,49	0,01	0,02
1420	Mediterranean and thermo-Atlantic halophilous scrubs (<i>Sarcocornietea fruticosi</i>)	1,90	0,03	0,08
5210	Arborescent matorral with <i>Juniperus</i> spp.	8,54	0,15	0,37
5230*	Arborescent matorral with <i>Laurus nobilis</i>	14,98	0,26	0,64
5320	Low formations of <i>Euphorbia</i> close to cliffs	36,75	0,64	1,58
5330	Thermo-Mediterranean and pre-desert scrub	454,53	7,73	18,97
6220*	Pseudo-steppe with grasses and annuals of the <i>Thero-Brachypodietea</i>	52,88	0,92	2,27
8210	Calcareous rocky slopes with chasmophytic vegetation	2,67	0,05	0,11
8310	Caves not open to the public	0,00	0,00	0,00
9260	<i>Castanea sativa</i> woods	3,76	0,07	0,16
9340	<i>Quercus ilex</i> and <i>Quercus rotundifolia</i> forests	1702,89	29,75	73,01
Natura 2000 habitat total cover area		2332,33	40,75	100,00
No Natura 2000 habitat total cover area		3390,95	59,25	
Mt. Argentario SAC total area (ha)		5723,28	100,00	

then calculated. The minimum mapping unit was assumed to be 2000 m². Habitat types covering only polygons smaller than 2000 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 scale (Main Map). A total of 13 habitat types listed in Annex I of Habitat Directive were identified, distributed in single and/or multiple typological units (Table 1). Only one habitat (Caves not open to the public – Natura 2000 code: 8310) had areas below the minimum mapping unit and was marked on the maps as points (see map). The Natura 2000 habitats cover more than 40% of the total SAC area and have a total area of about 2330 ha (Table 1). The territory not covered by conservation interest habitats consists of urban and industrial areas, arable land and tree cultivations (mostly olive groves and vineyards), and artificial conifer plantations. Also, some natural- and semi-natural habitat types (e.g. several high and low maquis typologies), rather widespread, are not included in Natura 2000 habitat list, as already noted in other Mediterranean areas (Viciani, Dell’Olmo, et al., 2016). Two habitat types (Arborescent matorral with *Laurus nobilis* and Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* – Natura 2000 codes: 5230 and 6220, respectively) are of priority interest, i.e. deserve particular importance for conservation (Commission of the European Community, 1992). They cover relatively small surface areas

(Table 1), but are important, at least at regional and national scale, because they are not widespread, especially Arborescent matorral with *L. nobilis* (Filibeck, 2006; Foggi, Chegia, et al., 2006; Biondi & Blasi, 2009). As shown in Table 1, the habitat types with higher cover values are sclerophyllous forests, followed by Mediterranean low matorrals and scrubs. The sclerophyllous forest habitat consists of woods dominated by *Quercus ilex* (Natura 2000 codes: 9340), which represents more than 72% of the total cover of the Natura 2000 habitat types of the SAC (Table 1). Small patches of *Castanea sativa* woods (Natura 2000 codes: 9260), of clear artificial origin (Arrigoni & Di Tommaso, 1997), are present in the northern slopes of the promontory. Low matorral and scrub formations (Thermo-Mediterranean and pre-desert scrub – Natura 2000 codes: 5330) cover a notable percentage of the habitat area (Table 1); this habitat includes different vegetation types: (i) one more widespread, formed by garrigues with *Erica multiflora*, *Cistus* sp. pl. and other woody species invaded and dominated by the large tussock grass *Ampelodesmos mauritanicus*, whose presence is encouraged by recurrent fires (Baldini, 1995); (ii) sporadic and small surface tree-spurge formations, dominated by *Euphorbia dendroides*, located in the more rocky, warm and arid slopes; (iii) very rare and sporadic garrigues, dominated by Palmetto (*Chamaerops humilis*), which reaches in the northern Tyrrhenian sea one of its northern distribution limits. The habitats of the coastal rocky cliffs are well-represented by (i) the ‘Vegetated cliffs with *Limonium* spp.’ (Natura 2000 code: 1240), which is important also from a biogeographic and conservation viewpoint, as it hosts the strict endemic *Limonium multifforme* (Fenu et al., 2016); (ii) the ‘Low formations of *Euphorbia* close to cliffs’ (Natura 2000 code: 5320), here dominated by

Helichrysum litoreum or *Anthyllis barba-jovis* (Brullo & De Marco, 1989; Biondi et al., 2000); (iii) the ‘Arborescent matorral with *Juniperus* spp.’ (Natura 2000 code: 5210), dominated by *Juniperus phoenicea* subsp. *turbinata* and other thermophilous species (*Olea oleaster*, *Pistacia lentiscus*, *Prasium majus*, *Teucrium fruticans*, etc., see Arrigoni & Di Tommaso, 1997). Some patches of halophytic habitats (Natura 2000 codes: 1310, 1410 and particularly 1420 – Mediterranean and thermo-Atlantic halophilous scrubs – see Table 1) are present in the eastern lowlands bordering the Orbetello Lagoon, where the halophilous vegetation is widespread (Andreucci, 2004). The inland rocky habitat is represented by ‘Calcareous rocky slopes with chasmo-phytic vegetation’ (Natura 2000 code: 8210); it is widespread in several sites located on very steep and southern-exposed rocky outcrops, but patches with mappable surface area are concentrated mainly in the area of Costa della Scogliera, above Cala Acqua Dolce (Main Map).

5. Conclusions

The production of an accurate habitat map represents an extremely valuable tool for knowing and managing a protected area, and the scale 1:10,000 can be considered accurate and highly suitable at regional and local scale, at least for Italy (Bagnaia, Bianco, & Laureti, 2009). Moreover, the EC Member States have to guarantee, at least for the Natura 2000 habitats for which a SAC has been designated, a Favourable Conservation Status, with requirements for monitoring and reporting (Commission of the European Community, 1992; Evans & Arvela, 2011; Ostermann, 1998) and the European and national methodological frameworks for monitoring conservation interest habitats consider habitat mapping as crucial (Angelini et al., 2016; Gigante, Attorre, et al., 2016; Janssen et al., 2016).

Producing such maps requires a significant commitment in terms of personnel, time and resources. Indeed, an accurate habitat map can be derived only from a previous detailed vegetation map, whose preparation generally involves a large amount of work, such as GIS analysis, field surveys, plant identification, creation of databases, statistical analyses, syntaxonomical checks, etc., performed by expert personnel (GIS and vegetation scientists). Even if, as in the case of Mt. Argentario, the phytosociological knowledge is almost entirely available, for the updating and checking of phytosociological and cartographic data, both in office and in the field, and for the conversion of such data to habitat information, at least the work of two experts for a few weeks is necessary.

To periodically check their conservation status and trends, and to verify if the EU biodiversity policy has been effective (Evans, 2012; Henle et al., 2013), in Europe Annex I Habitats monitoring is mandatory

every six years for the countries belonging to European Union (Commission of the European Community, 1992; Gigante, Attorre, et al., 2016). Nevertheless, only in recent times, this task begins to be standardized and coordinated, at least at the national level in Italy (Angelini et al., 2016; Gigante et al., 2018; Gigante, Attorre, et al., 2016). Considering the high number of Natura 2000 Special Areas of Conservation in Italy (only in Tuscany they are 131), it must be noted that without adequate and recurrently financial resources granted by regional and national administrations, habitat monitoring risks being able to be realized only partially.

Software

The maps were created and edited using the software *ESRI ArcGIS 10.4*.

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