MONITORING CHANGES OVER A 10-YEAR PERIOD, THROUGH VEGETATION MAPS, IN A COASTAL SITE IN APULIA REGION (SOUTHEASTERN ITALY)

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Abstract – This study aims to detect, analyze, and evaluate the habitat changes, between 2010 and 2020, occurred in the Mediterranean wetland system of “Zone Umide della Capitanata e Paludi presso il Golfo di Manfredonia”. We classified habitats in 2020 using Eunis classification and compared the obtained map with the Eunis map of 2010, obtained using the same approach, in terms of class area, Magnitude of Changes and the corresponding Trend Percentage of Change. It emerged that expansion of agricultural activities and alterations of the hydrological regime are behind most of the observed changes.

Introduction

Coastal wetlands are among the most essential and valuable ecosystems on Earth, characterized by high biological diversity and providing a variety of ecosystem services [18; 7]. In Mediterranean, these environments are considered biodiversity hotspots, including a wide range of endemic species, but subject to numerous threat factors, such as land claim, agricultural intensification, hydrological modifications, urbanization, coastal erosion and introduction of alien species [11; 15; 12; 13].

Consistent monitoring procedures, as well as awareness of the ongoing socio-economic dynamics, are fundamental to implement effective management policies and conservation strategies. Assessing changes in landscape ecological elements through habitat monitoring over a long period is essential to: a) understand the drivers of the temporal changes; b) make provisions for future trends, c) design appropriate conservation policies [10; 14; 5].

The aim of this work is to detect, analyze, and evaluate the habitat changes occurred in one of the largest components of the Mediterranean wetland system, between 2010 and 2020.

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Material and methods

The site “Zone Umide della Capitanata e Paludi presso il Golfo di Manfredonia” [Site of Community Importance (SCI) IT9110005; Special Protection Area (SPA) IT9110038], located in the north-eastern part of the Puglia region and partially enclosed in the Gargano National Park (Figure 1), is one of the most extensive wetlands of the Italian peninsula (more than 14 000 ha) and one of the largest components of the Mediterranean wetland system. It is also classified as Ramsar site and Important Bird Area (IBA 230 M).

The site has been subject to human exploitation for a long time, mainly for agricultural purposes, resulting in the conversion of large part of the wetland areas into cultivated lands and the subsequent reduction and fragmentation of the original natural habitats. Due to this process, at present, a large part of the area is either devoted to agriculture or else abandoned. The remaining humid areas consist of a system of lagoons, characterized by brackish or saltwater, depending on the specific water regime. The natural vegetation is formed mostly by halophytic scrub and reed thickets and by annual pioneer salt marsh communities [16].

Figure 1 – SCI “Zone Umide della Capitanata e Paludi presso il Golfo di Manfredonia”.

The habitat map was produced by visual photointerpretation at a scale 1:5 000, digitized in ArcGis 10.2 from colour orthophotos realized between 2019 and 2020 within the project COHECO (https://www.coheco.it) in three different months (February, June and October).

After the identification of natural and semi-natural landscape elements as vegetation types, defined on the base of phytosociological units according to the Zurich-Montpellier method [3], vegetation units were reclassified in habitat types based on the EUNIS classification scheme, according to the habitat classification revised 2004 (levels III and IV; [9]). The map thus generated was compared to a EUNIS habitat map, referring to 2010 and produced at the same spatial scale [17].

Trend Percentage of Changes (TPCs) in class area occurred between 2010 and 2020 for each habitat class was calculated by using the following formulas [1; 2]:

$$TPC_i = \frac{MC_i}{CA_i(T1)} \cdot 100$$

where: $MC_i = CA_i(T2) - CA_i(T1)$

i is the habitat considered and, for the case under study, *T1* and *T2* correspond to 2010 and 2020, respectively. *CA* represents the Class Area recorded for each class.

Results and discussions

Cultivated areas are the predominant type, covering about the 40 % of the site. Natural and artificial water bodies cover about the 38 %, with the class X02 (saline coastal lagoons, corresponding mostly to the Margherita di Savoia salines) amounting to the 30 %, thus making up the dominant element of the natural landscape.

The most represented vegetation types are helophytic communities (with numerous habitat types, of which the most extensive is C3.2 [Water-fringing reedbeds and tall helophytes]) and halophytic shrubs and annual herbaceous communities of saline to hypersaline environments (with the habitat types A2.526 [Mediterranean saltmarsh scrubs]; A2.516 [*Suaeda vera* saltmarsh driftlines]; A2.551 [*Salicornia*, *Suaeda* and *Salsola* pioneer saltmarshes]).

Despite the coastal strip having an extension of over 30 km, the sandy coast system, including both vegetated and not vegetated areas, covers less than 1 % of the whole area. This is due to the severe coastal erosion and other anthropogenic pressures that are exerted on this environment, as will be discussed below.

It can be said that the general composition of the landscape, in terms of large categories (salt marshes, coastal lagoons, sandy dune system) has not changed much from 2010 to 2020. However, if we look in detail at the single habitat types that make up these systems, numerous changes can be described, some of which are also very significant. The class area (CA) recorded for each class in 2010 and in 2020, and the corresponding TPC, are reported in Table 1.

Table 1 – Class area (CA) in 2010 and 2020, and Trend Percentage of Change (TPC).

Habitat	CA in 2010 (ha)	CA in 2020 (ha)	TPC (2010-2020) (%)
A2.1	-	9.59	-
A2.5	306.65	-	-100.00
A2.515	30.31	15.65	-48.37
A2.516	-	65.89	-
A2.522	44.05	129.26	193.43
A2.525	-	190.65	-
A2.526	1000.39	863.25	-13.71
A2.53C	38.68	47.04	21.61
A2.53D	111.97	15.60	-86.06
A2.551	257.36	110.06	-57.23
B1.1	1.51	4.33	186.85
B1.2	81.50	67.56	-17.11
B1.31	20.64	25.68	24.43
B1.4	16.00	6.44	-59.76
B2.1	2.28	0.84	-63.15
C1.3	218.33	263.77	20.82
C2.3	64.251	72.90	13.47
C2.4	11.69	11.37	-2.73
C3.2	850.98	923.13	8.48
E1.61	573.75	374.84	-34.67
F5.514	-	0.62	-
F9.31	34.65	33.58	-3.11
FB.4	18.50	23.68	27.97
G1.D	1.83	15.48	744.77
G2.81	21.00	18.85	-10.23
G2.83	-	10.24	-
G2.9	0.32	0.33	0.00
G2.91	66.67	76.35	14.52
G3.F	35.75	34.03	-4.80
I1.1	3700.56	3649.68	-1.37
I1.2	1329.28	1749.22	31.59
J1.1	36.68	36.95	0,73
J1.2	141.76	145.58	2.69
J2.1	54.82	54.79	-0.06
J2.3	52.38	41.45	-20.89
J2.4	52.77	52.45	-0.64
J2.6	2.03	1.465	-28.04
J2.7	0.23	-	-100.00
J4.2	17.96	53.10	195.70
J4.5	4.89	3.90	-20.22
J4.6	23.04	18.47	-19.86

Habitat	CA in 2010 (ha)	CA in 2020 (ha)	TPC (2010-2020) (%)
J5.1	9.89	42.09	325.68
J5.2	6.54	10.29	57.33
J5.3	2.59	2.53	-2.40
J5.4	1.85	1.96	6.04
X02	4402.13	4372.01	-0.68
X03	442.33	460.10	4.22

In general, most of the observed transformations is borne by habitats referable to the EUNIS high level categories A (marine habitats, included saltmarshes and coastal lagoons), and B (coastal habitats, included coastal dunes and beaches) [9].

As shown in Table 1, class A2.5 (Coastal saltmarshes and saline reedbeds), covering more than 300 ha in 2010, in 2020 is totally converted in other classes, due to:

a) thematic redefinition of this coarse class in more detailed types (e.g., A2.526 and A2.551); this increment in thematic resolution resulted from a more detailed in-situ survey of the investigated plant communities, thus allowing a more accurate discrimination between different habitat types (according to the same EUNIS classification scheme);
b) real changes, such as the conversion of A2.5 into A2.522 (Mediterranean *Juncus maritimus* and *Juncus acutus* saltmarshes) and A2.525 (Mediterranean *Juncus subulatus* beds). These transformations have occurred because of alterations in the hydrological regime, both in terms of water salinity and of the flooding period.

On the other hand, five new classes have been introduced in 2020: A2.1 (Littoral coarse sediment), A2.516, A2.525, F5.514 (Lentisc brush), G2.83 (Other evergreen broad-leaved tree plantation), because of a higher thematic redefinition.

In terms of change in surface area, the most striking changes within the group A concern the classes A2.5, A2.522, A2.53D, A2.551. As mentioned above, the class A2.5 is entirely replaced by other classes. A2.526 undergoes a quite relevant reduction (TPC = -13.7) with multiple conversions in numerous other classes, mainly in arable lands, with a loss of natural areas; this trend is quite widespread throughout the whole area, and particularly evident in the marginal areas bordering the cultivated fields (Figure 2).

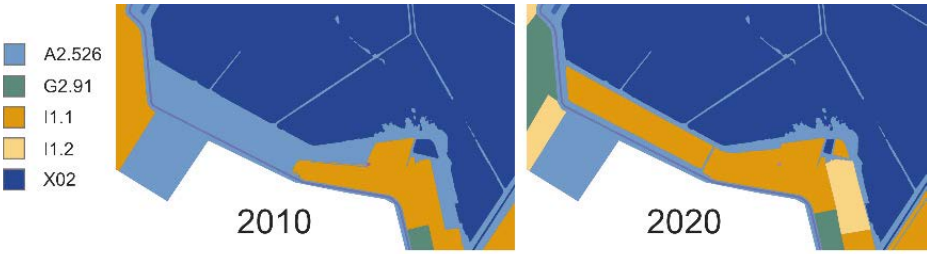

Figure 2 – Conversion of A2.526 into arable land.

Numerous helophytic communities of salt marshes show important changes in cover: the surface area of class A2.522 triplicates, from 44 to 129 ha (TPC = 193.4 %); the class A2.53D suffers a drastic reduction, from 112 to 16 ha (TPC = -86 %); A2.515 (*Elymus repens* saltmarsh driftlines) reduced too, halving its surface from about 30 to 16 ha (TPC = -48.4 %); A2.53C (Saline beds of *Phragmites australis*) increases its surface (TPC = 21.6 %). These dynamics are particularly evident in the northern part of the site, mainly due to complex modifications of the water regime (Figure 3). Finally, habitat A2.551 drastically reduces, from about 260 to 110 ha (TPC = -57.2 %), in this case due to changes in land management.

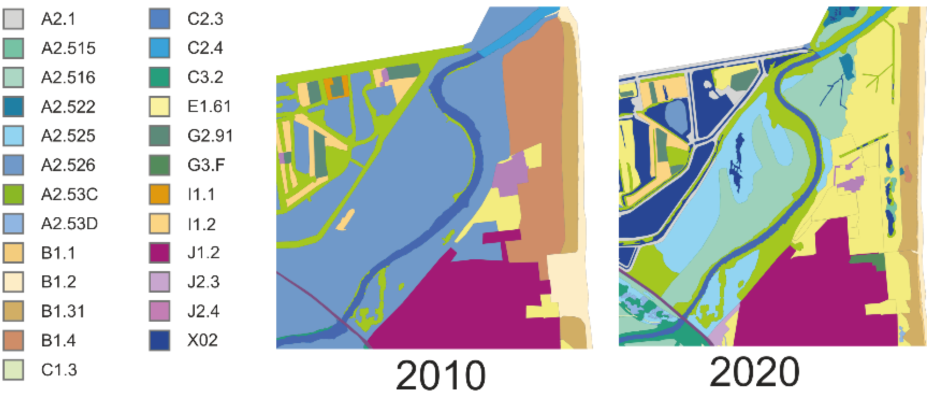

Figure 3 – Drastic reduction of class A2.53D in the northern part of the study area.

As regards the sand dune system, important transformations have been observed, with processes of erosion (in the southern part of the site) and accretion (in the northern part of the site) resulting in a general reshaping of the coastline. Class B1.1 (Sand beach driftlines) expands (TPC = 186.8 %), and class B1.31 as well (TPC = 24.4 %), even if this increment is the result of drastic rearrangements of the surface areas of these habitat types, with multiple conversions in various other classes, such as E1.61, B1.4, B1.2 (Figure 4). Habitat B1.4 is interested by a general reduction (TPC = -59.8 %) and drastic transformations: in fact, the area covered in 2010 is entirely converted, mostly in E1.61 (Figure 3), while new areas of B1.4 derive from the conversion of B1.31, B1.2 and B1.1. It should be pointed out that coastal erosion is an ongoing trend in a large extend of the sandy coats of almost the entire Apulia Region. In fact, since the early twentieth century, the realization of coastal railway lines and road system, along with a massive reclamation of wetlands, has triggered the transformation of the coastline; moreover, sediment trapping and river regulation actions contributed to reducing watershed sediment input. This coastal evolution has led, along with intensive touristic exploitation of coastal areas, to a gradual reduction of dunes belts and the related habitat types [8; 4].

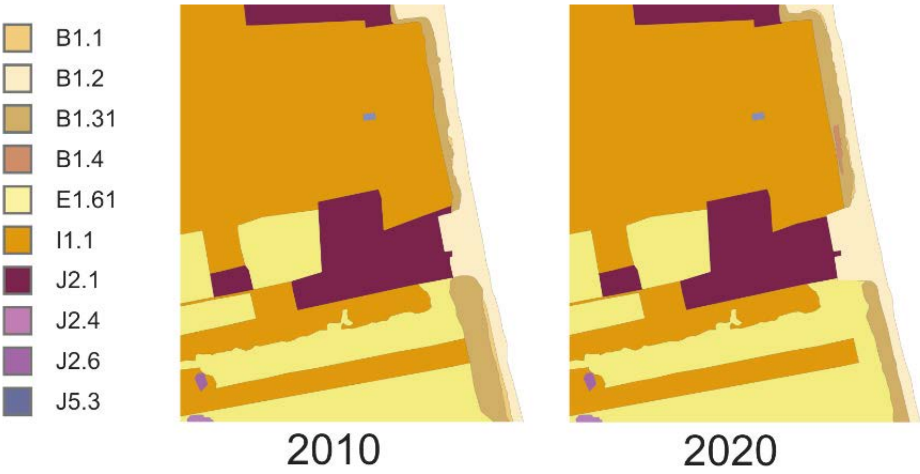

Figure 4 – Rearrangement of the sand dune system in the middle part of the site, with expansion of cultivated areas.

Class C1.3 increases its surface (from 223 to 264 ha; TPC = 18.1 %), especially from the transformation of the classes A2.551, E1.61 and C3.2. This is the result of important interventions of a LIFE+ project realized in the Natural Oasis "Lago Salso" (Figure 5).

Class F9.31 (*Tamarix* communities) undergoes a reduction (TPC = -3.1 %) but with important rearrangements of its spatial distribution, with conversions in the classes A2.522 and C3.2.

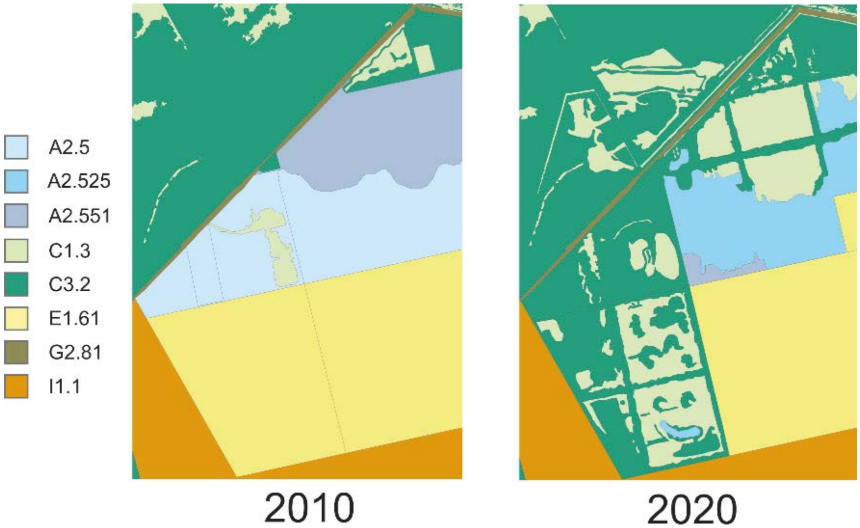

Figure 5 – Increasing of class C1.3 at "Lago Salso".

Class E1.61 reduces its surface (TPC = -34.7 %) with the conversion in arable lands. There is the significant increase of cultivated areas, in particular arable lands I1.2 (TPC = 31.6 %), from conversion of E1.61 but also from saltmarsh natural areas, especially A2.551, A2.526; this trend corresponds to loss in natural areas.

Numerous anthropogenic pressures are behind most of the observed changes. Intensification and expansion of agricultural activities and alterations of the hydrological regime are among the main driving forces exerting pressures on the observed natural systems. The uncontrolled extraction of groundwater seems to be at the basis of the subsidence which is occurring in some parts of the site, and which is leading to radical landscape transformations [6].

Conclusions

The impact of human activities on the Mediterranean wetland systems may undermine their future ability to survive as self-regulated systems. For this reason, the need for economic growth should be compatible with environmental policies avoiding overexploitation of natural resources, with particular attention to the management of the water resources.

Understanding the complex and intricate connections among ecological, social, and economic goals is essential in implementing management and conservation policies. Policymakers at different administrative levels should try to find a compromise between both private and public goods for an efficient and consensual program of the management of natural resources.

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