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Coastal dynamics vs beach users attitudes and perceptions to enhance environmental conservation and management effectiveness

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ABSTRACT

This work carries out a landscape analysis for the last 60 years to compare the degree of preservation of two areas on the same Italian coastline characterized by different environmental protection levels: a National designated protected areas and a highly tourist coastal destination. The conversion of natural land-covers into human land uses were detected for protected and unprotected coastal stretches highlighting that the only establishment of a protected area is not enough to stem undesirable land-use outcomes. A survey analysis was also conducted to assess attitudes of beach users and to evaluate their perception of natural habitats, beach and coastal water quality, and coastal dynamic over time. The results of 2071 questionnaires showed that there is similarity between subjective and objective data. However, several beach users perceived a bad quality of coastal water in the legally unprotected coastal area. The implications from a planning and management perspective are discussed.

1. Introduction

Coastal areas are among the most productive ecosystems worldwide and are crucial for humans because they deliver a flow of valuable ecosystem services that include marketable goods and products, such as fisheries and recreational opportunities, and non-marketed services, like natural hazard regulation (e.g. erosion control), nutrient cycling, and wildlife habitats (e.g. Barbier et al., 2011; Ghermandi and Nunes, 2013; Liquete et al., 2013; Potts et al., 2014; Wilson et al., 2002). However, coastal areas are exposed to changing environmental pressures because of their spatial location and attributes (Turner and Schaafsma, 2015). The increased human pressures due to tourism, pollution, eutrophication, urbanization, land reclamation, and over fishing altered the most ecologically important and valuable coastal features, processes and functions to obtain additional social and economic benefits (e.g. Batista et al., 2014; Ducrotoy and Yanagi, 2008; Lejeusne et al., 2010; Lotze et al., 2006; van der Meulen and Salman, 1996), particularly in the case of sandy beaches (Acosta et al., 2006; Brown and McLachlan, 2002; Defeo et al., 2009; McLachlan et al., 2013; Schlacher et al., 2007). As a consequence, beaches and coastal dunes disappeared in many locations, and several ecosystem services are degraded or lost, such as the provision of food and nesting habitat to migratory birds, storm protection, nutrient recycling, coastal protection against erosion, decreased scenery of beaches, as well as the recreational opportunities (EC, 2014; MEA, 2005).

Sustainable management of coastal areas is one of the main challenges humanity is facing today because it must ensure the maintenance of the natural structure and functioning of ecosystems in order to provide ecosystem services (Turner and Schaafsma, 2015) for current and future generations (Ducrotoy and Yanagi, 2008). However, complementary human assets, such as skills, time, money and energy are then required to extract societal goods and other benefits from such services (Atkins et al., 2014).

The increasing concern on these issues has encouraged scientific and policy arenas to reconcile the human needs in coastal region development by implementing, actions for the environmentally sustainable exploitation of the coastal zones through informed decisions (Borja et al., 2017).

Understanding the key processes that structure ecosystems is crucial to design and implement effective long-term management plans of natural resources (Holling and Meffe, 1996). Several studies (e.g. Aretano et al., 2013; Ellis et al., 2011; Malavasi et al., 2013; Potter, 2013; Shalaby and Tateishi, 2007) demonstrated the effectiveness of multi-temporal landscape analysis to identify the main processes

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driving changes in the ecosystem and their effects over time. The assessment of land use and land cover change trends over time is a significant tool for decision-making in conservation and environmental assessment even though it is not always possible to establish clear cause-effect relationships. For instance, it can be used to identify particularly critical or vulnerable locations, deserving special consideration from stakeholders and decision makers, in order to improve the effectiveness of conservation policies by establishing protection priorities and specific management strategies (e.g. Falcucci et al., 2007; Martínez-Fernández et al., 2015; Petrosillo et al., 2009; Ruiz-Benito et al., 2010; Sánchez-Cuervo et al., 2012).

Coastal areas are complex socio-ecological systems characterized by interactions between ecological structure and functioning, physico-chemical processes and where multiple socio-economic interests coexist (Elliott et al., 2017; Marin et al., 2009). In this perspective the management of coastal resources should reflect the relationships among all ecosystem components, including humans, as well as the resulting socioeconomic impacts (Yáñez-Arancibia et al., 2013). In addition, to reach a consensus for sustainable management of coastal systems and their resources, it is necessary the support of all sectors of administration (EC, 2007; Newton and Elliott, 2016) and the engagement of their different stakeholders, such as local communities, landowners, visitors, decision makers, as key actors in coastal planning and management (e.g. Bell et al., 2013; Borja et al., 2017; Brown et al., 2016; Petrosillo et al., 2013). This issue is particularly important for beaches, since they represent a major attraction and a primary resource of local economy in many coastal areas worldwide, attracting more tourists and recreational users than any other coastal ecosystem (Hall, 2001; Maguire et al., 2011; Marin et al., 2009).

Many coastal zones, including both landscapes and seascapes, are designated as natural protected areas to protect natural capital and/or relevant cultural heritage for a broad range of human activities. However, there are different levels of protection/management that may range from highly protected areas where no extraction, deposition or other damaging activities are allowed, to areas where only minimal restrictions are needed to protect the features (Potts et al., 2014).

In order to give a contribution to face the above challenge, this paper aims to explore the landscape dynamic given by 60 years (1954–2013) and the attitude of users both within protected areas (national park) and outside, across the wider landscape. This analysis may be used to assess whether the levels of protection proposed over time have been effective in ensuring the long-term conservation and management of natural resource inside the protected coastal area, such as avoiding or mitigating undesirable landscape changes caused by increasing human demand inside and outside the protected area. In addition another aim of the research was to investigate the beach users attitudes and perceptions of the issues that can affect the environmental quality of beaches in the two coastal areas (protected and non-protected). In this perspective, a survey analysis was specifically designed to determine beach users perceptions about coastal features, quality of coastal water and the coastal evolution over time. The accuracy of beach users perceptions has been compared with the objective data resulting from a landscape change analysis and official statistics on the quality of coastal waters. The possible implications of the results from a planning and management perspective are discussed.

2. Materials and methods

2.1. Study area

The study area (Fig. 1) is located in a wide coastal plain covering a surface of about 12,000 ha and stretching for about 44 km along the coast of the municipalities of Latina, Sabaudia, San Felice Circeo and Terracina in the province of Latina (Latium, Italy). In this area it is possible to identify two zones separated by the promontory of Circeo: 1) the coastal area of Latina and Sabaudia that includes the Circeo National Park (about 25 km) that we will denote as “protected coastal area”, and 2) the coastal area of San Felice Circeo and Terracina (about 10 km) that we will denote as “unprotected coastal area”.

The Circeo National Park has been established with the Italian Law n. 285/1934 with the objective to preserve, protect and enhance the natural heritage and to promote the development of tourism and eco-compatible businesses. Currently, the Park extends for an area of 8,9 ha encompassing five main ecosystems: the plain forest, four coastal lagoons (Sabaudia, Caprolace, Monaci and Fogliano), separated from the sea by coastal dunes, the promontory of Circeo, with a maximum elevation of 541 m and the island of Zannone. The protected coastal area is characterized by an extensive dune system with a raised ecological value due to the presence of priority and community habitats identified under the EU Habitats Directive 92/43/CEE as Coastal dunes with *Juniperus* spp., *Malcolmietalia* dune grasslands and *Brachypodietalia* dune grasslands.

On the other hand, the sandy coastal area in San Felice Circeo and Terracina, is urbanized and characterized by private and public beaches, holiday houses and tourism infrastructures. The resulting “waterfront” is, thus, characterized by a low degree of naturalness and a high density of urban and logistic facilities related to tourist activities.

2.2. Land use and land cover change analysis

Three vector land cover maps were produced for the years 1954, 1988, and 2013 to investigate the coastal dynamics during the period from 1954 to 2013. These maps were obtained from the interpretation and digitization, in a GIS environment (ArcGIS 10.1 ©ESRI), of aerial ortho-photos taken during the summer at about 1 m resolution.

The choice of an appropriate land cover classification system represents a crucial step in the evaluation of landscape management (Wilson et al., 2002), since it contributes to the knowledge of the phenomena in progress. The land cover classification system used in this research is based on the European CORINE (Coordination of Information of the Environment) Land Cover project that uses a hierarchical nomenclature in three levels, which is homogeneous across Europe (EEA, 2007).

The third level of detail for natural and semi-natural areas was extended in this work in order to distinguish coastal features such as beaches, natural dunes and dunes that were modified by human activities, here called “human-modified dunes” (Fig. 2). As a result, eight land cover types were identified and mapped (Table 1) to describe both spatial and temporal coastal dynamics and to assess changes in natural capital. The topological consistency of polygonal coverage in the map was verified and validated through field surveys.

Based on the three land cover maps, for 1954, 1988, and 2013, a change detection (CD) analysis was carried out. CD identifies a collection of methods of analysis that evaluates and quantifies changes in patterns within the landscape at the time T_1 compared to the time T_2 ($T_1 + \tau$) (Singh, 1988). For this reason the CD analysis represents an optimal tool to identify the locations of land use changes and also the direction and magnitude of these changes. The overlay of land cover maps has been performed by using the topological operation of “intersection”, which allows creating a new digital land cover map derived from the two maps at the time T_1 and T_2 where the new polygon generated retain the attributes of the original ones. In this way a transition matrix was obtained showing the changes in the landscape mosaic by contrasting the surface of land cover types of the map at time T_1 (rows) and those of the map at time T_2 (columns). At the time T_1, landscape features (land-covers) have a certain distribution in the landscape considered. After a period of time (T_2), each of them can remain intact or partly (or all) converted into another feature (land-cover). The totals per row and per column indicate the surface of each land cover type at the time T_1 and at the time T_2 respectively. The main diagonal line refers to the surface of land cover types remaining unchanged during the time window considered (Supplementary Fig. 1).