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Research Article

Valuation, assessment and mapping of Ecosystems Services of the Site of Community Importance "Dunas de Mira, Gândara e Gafanhas" (Portugal); Methodological Approach

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Abstract: Putting value to ecosystem services is something that society still refuses or simply ignores because it is not aware of the benefits that ecosystems provide us. In fact, people should be aware that a good understanding of ecosystem services can lead to win-win situations. Being aware of the importance of preserving the ecosystem and attaching value to its services will enable the development of self-sustaining strategies and appropriate policies for better ecological governance. Decades of over exploitation of natural resources, introduction and spread of alien species and, also, climate change, forest fires among other threats, have fostered biodiversity loss. The European Union Biodiversity Strategy has as one of its main goals to stop biodiversity loss and the degradation of ecosystem services; if possible, to recover the most threatened and degraded ecosystems, based on 20 Actions divided into 6 Targets. The present work falls within the scope of Action 5 of Target 2 – Improve knowledge of ecosystems and their services in the EU. The specific focus of this study is the Site of Community importance "Dunas de Mira, Gândara and Gafanhas" (Portugal) and the assessment of its ecosystem services, in accordance with the methodology proposed by the MAES (Mapping and Assessment of Ecosystems and their Services) Working Group. The work currently under way, a small segment of which is presented here, aims to identify, map and, when possible, assign value to the ecosystem services. For this purpose, modern GIS technologies will be used. This approach was implemented using a combination of data and tasks, including the photo-interpretation of Sentinel 2 (COPERNICUS Program) satellite imagery. The data geoprocessing tasks and image segmentation were developed using QGIS software and IMPACT Toolbox software (developed by the Joint Research Center – JRC, of the European Union), respectively. The analysis of Land Use and Burned Areas maps for the SCI "Dunas de Mira, Gândara and Gafanhas" led us to conclude that Forests ecosystems, the most affected by the fire of October 2017, continue to have the greatest expression in the area under study even though they have lost more than 50% of the area, and their services were also the ones most affected by the fire.

Keywords: ecosystem services; valuation; monetization; assessment; mapping, biodiversity; Geographic Information Technologies

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1. Introduction

The services that the ecosystems generate, and which are vital for our survival, are numerous. And yet we are often not even remotely aware of their importance, diversity and usefulness. Such services are classified according to the benefits they provide to society. They include provisioning services such as plant derivatives (raw materials or energetic materials), regulating services such as those provided by wetlands (air and water purification, regulation of the water cycle, flood prevention), or by pollination, support services (nutrient cycling, photosynthesis, soil formation) and, finally, cultural services and invaluable services having to do with the use of nature for purposes of recreation, reflection, health, and cultural heritage. In Portugal, the legal definition is given in the Law on nature and biodiversity, dated 2008 (Article 3q of Decree-Law No. 142/2008, July 24).

Ecosystem services have been neglected because of the tremendous pressures that drive development – read economic growth – and because the value of the services provided by nature remains invisible to citizens, to decision-makers, to the economy, and to governments.

It is important to distinguish between valuation, enriching (valorization) and evaluation or assessment [1]. According to the author, valuation is what makes it possible to put a price, that is, to attribute the monetary value to be paid for the use of natural resources and received for the conservation of ecosystem services, that is, assigning value. On the other hand, enriching, conveys the notion of increasing, adding value to natural areas and services. As for the assessment of biodiversity, it refers to the identification of the natural values of a given location (*idem*, *ibidem*).

Setting the focus primarily on environmental valuation, Kenter et al., [2] argue that "Valuation is therefore distinguished from valuing. We consider the latter as an informal, largely implicit process not bound to any particular setting, while the former relates to formal research, analysis or decision-making processes where values (of various types) are explicitly expressed (e.g., in surveys or workshops) or deduced (e.g., through content analysis of media).

Concerning the goals of the process of mapping and assessment of ecosystems and their services, it seems to be accepted that it can be very useful by helping decision-makers in identifying priority areas and relevant policy measures, including improving the targeting of such measures and demonstrating/assessing their cost-benefit ratio [3].

1.1. The Survey area

The classification of the Site of Community Importance (SCI) "Dunas de Mira, Gândara and Gafanhas" (PTCON0055) was established by Council of Ministers Resolution no. 76/00, of 5 July. It covers a total area of 20 511 hectares, encompassing the municipalities of Vagos, Mira, Cantanhede and Figueira da Foz [4], (Figure 1).

The study area is located on Portuguese Western Coast, which stretches from Espinho to Cape Mondego. This is a coastal region formed by a quasi-straight sand-barrier with a N14º E orientation [5]. In this part of the Portuguese coastline, the vast accumulation of dune sands stretches deep inland [6,7]. As for the morphology (Figure 2), it is characterized by being relatively flat and of low altitude [8,9]. The section of the coast comprised between Espinho and Cape Mondego is part of the morphosedimentary environment of Portuguese Western Meso-Cenozoic sedimentary basin. In terms of geological structure sedimentary formations that are diverse with regard both to the age and type of rocks (Figure 3), build the core of the area [10]. Excluding the Cape Mondego area (limestone and Jurassic marls), this coastal region consists mostly of sandy formations [11,12].

The climate of the region is temperate, with mostly Mediterranean features (hot, dry summers and mild, rainy winters), and moderately influenced by the Atlantic Ocean [13].

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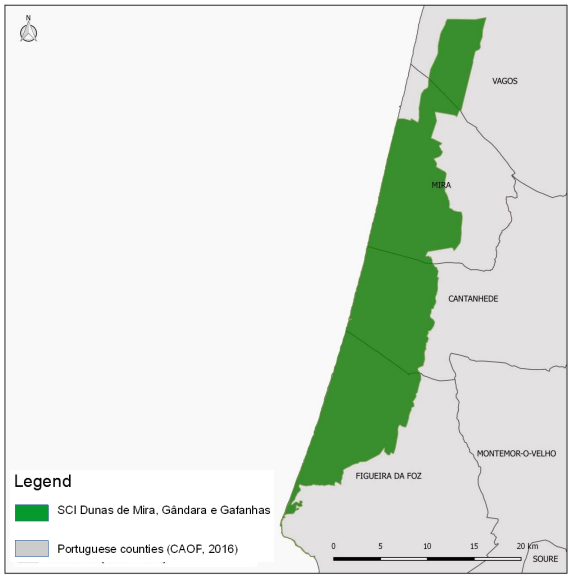

Figure 1 - Geographical setting of the study area.

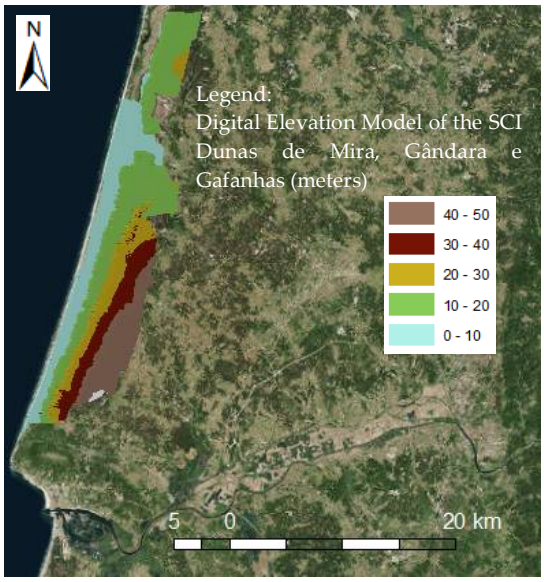

Figure 2- The Site of Community Importance "Dunas de Mira, Gândara e Gafanhas"- DEM.

As far as hydrography is concerned, there are several freshwater lagoons, such as the Barrinha de Mira, Lagoa, and Lago do Mar in the municipality of Mira, Lagoa dos Teixoeiros and Lagoa da Salgueira in the municipality of Cantanhede, and Lagoa da Vela, Lagoa das Braças and Lagoa do Paial in the municipality of Figueira da Foz. In addition to these lagoons, there is the temporary flooding of other areas. Mention should also be made of a number of streams, such as the Lavadia ditch, Sandoa ditch, Lagoa ditch, Escoural ditch, and the Cana ditch. This set of small water tables delimits a set of ecosystems that fall within the terminology of the National Ecological Reserve Act (REN), specifically as provided by its Article 4.

In edaphic and pedologic terms, the coast extending from Espinho to Figueira da Foz is formed by Arenosols [14] - to use the FAO (UN Food and Agriculture Organization) classification -, also called Psammitic Regosols according to the Portuguese classification. These are light-colored sandy soils, derived from quartz-rich materials or dune and beach sand; Arenosols are characterized by a coarse texture and low organic matter content as well as low fertility (*idem, ibidem*).

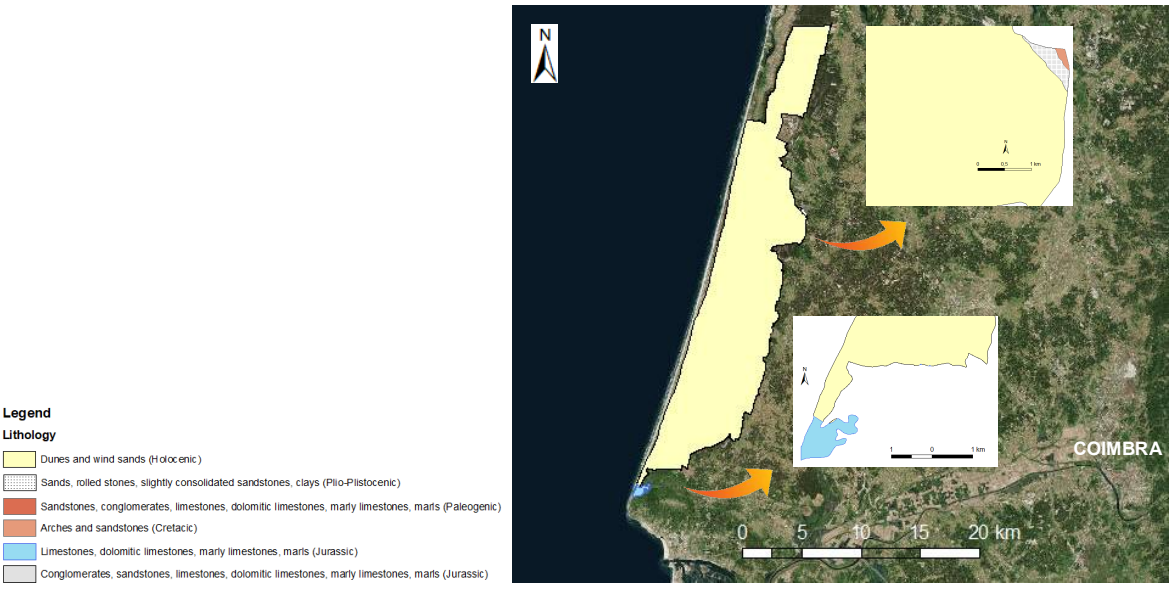

Figure 3- The Site of Community Importance "Dunas de Mira, Gândara e Gafanhas" - Lithologic map.

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1.2. Terminological and conceptual framework

In the last few years, a significant amount of work has been devoted to the monetary valuation or "monetization" of the multitude of services that nature renders to human societies [15]. This Monetization of Ecosystem Services (MES) has been advocated by many authors as an optimal strategy to make nature visible to decision makers and financial markets, with the hope that this would lead eventually to the sustainable use of natural resources and their preservation. Thousands of articles have been devoted so far to MES, addressing a wide range of aspects of the topic, from its theoretical foundations to practical attempts at assigning monetary values to specific ecosystem services. In parallel to these academic pursuits, many international organizations, and more and more governmental agencies in numerous countries, are elaborating policies based on MES or on the occasionally-related "Payments for Ecosystem Services" (PES). As Renarda *et al.*, (2015) [16], it is our belief that "Managing multiple ecosystem services, including addressing trade-offs between services and preventing ecological surprises, is among the most pressing areas for sustainability research".

The concept of ecosystem services, which politically was first adopted at the international level in 2000 at the United Nations Millennium Summit, following the Secretary-General's report to the Assembly "We the People" [17], has become crucial to our understanding of how humans interact with the natural environment [18]. But it was perhaps because of the writings of Daily (1997) [19] and Costanza *et al.*, (1997) [20] that in less than three decades ecosystem services grew exponentially as a field of research, in terms of the number of publications devoted to the subject [21].

The concept originated in the green, environmental or natural resource economy, whose main component is the value of nature and of the services provided by it [22]. But the definition is too broad to win general acceptance, as it makes it difficult to establish accounting units [23,21] and does not meet with agreement on the part of some traditional communities. That is the case of Andean culture and its refusal to deal instrumentally with ecosystems, which those communities view as "Mother Nature".

To quote Daily (1997) [19] "ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life." According to Rodrigues (2015) [24], ecosystem services have to do with "conditions and processes" and illustrate an interaction between ecology and human well-being, and for other authors [20, 23, 25, 26] "Ecosystem Services are nothing but the benefits they provide to people. Other authors [20] (p. 253) offer a more concrete definition: "ecosystem goods (…) and services (…) represent the benefits human populations derive, directly or indirectly, from ecosystem functions." According to Alcamo *et al.* (2003) [27], "Ecosystem Services are the benefits people obtain from ecosystems, which the [Millennium Ecosystem Assessment] describes as provisioning, regulating, supporting, and cultural services[1]. According to Boyd & Banzhaf (2007) [23], the definition proposed by Alcamo *et al.* (2003) [27] points in the right direction as far as the quantification of ecosystem services is concerned. However, some of them (*e.g.* regulating services) are mostly ecosystem functions and processes [28].

[1] In this context we would also like to mention the proposal contained in the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) Conceptual Framework, which defines the new "8" category in the following terms: "... 'Nature's benefits to people' refers to all the benefits that humanity obtains from nature. Ecosystem goods and services, considered separately or in bundles, are included in this category. Within other knowledge systems, nature's gifts and similar concepts refer to the benefits of nature from which people derive a good quality of life. Aspects of nature that can be negative to people, such as pests, pathogens or predators, are also included in this broad category. All nature's benefits have anthropocentric value, including instrumental values – the direct and indirect contributions of ecosystem services to a good quality of life, which can be conceived in terms of preference satisfaction, and relational values, which contribute to desirable relationships, such as those among people and between people and nature, as in the notion of 'living in harmony with nature' ".

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Boyd and Banzhaf (2007) [23] argue that one must distinguish between final and intermediate services if one is to establish different enhancement measurements. Final ecosystem services are those components of nature that are directly enjoyed, consumed or used as an end-product for the well-being of humans, whereas intermediate services are those services that are embodied in the production of the final services, hence for purposes of economic appreciation. Final services thus have greater value, given that their evaluation already takes the intermediate services into account. the distinction is crucial, to ensure that the value of intermediate services is not double-counted.

Fisher *et al.* (2009) [21] define ecosystem services as the parts of ecosystems that are either actively or passively used to produce human well-being. They are ecological phenomena that do not necessarily have an immediate use. Unlike, Boyd and Banzhaf, and Fisher *et al* [23,21] view the processes and functions of ecosystems as services that can be directly or indirectly consumed or utilized by humans. This agrees with Rodrigues's claim (2015) [24] that there is a service whenever there is a benefit to society.

Based on the Millennium Ecosystem Assessment approach, the Economics of Ecosystems and Biodiversity initiative defines ecosystem services as "the direct and indirect contributions of ecosystems to human well-being" [28]. Finally, mention should be made of the Common International Classification for Ecosystem Services (CICES) initiative, in which "ecosystem services" are defined as "the contributions that ecosystems make to human well-being. They are seen as arising from the interaction of biotic and abiotic processes."

1.3. Goals

In short, this study aims to help expand existing knowledge on the present condition of ecosystems and their services (not only in the European Union but also globally, as significantly attested to by the issue of carbon sequestration) with a view to improving the well-being of humankind.

The general goals of the study are the following:

- to contribute to raise awareness of the importance of stopping biodiversity loss in forest ecosystems along the Portuguese coast;
- to contribute toward quantitative, objective knowledge about ecosystems and their services;
- to serve as a tool to support spatial planning, by improving policies aimed at conserving and valuing ecosystems and by correcting those policies (whether relating to industry, urban development, transport, agriculture, forestry, etc.) most likely to cause harm to ecosystems.

The specific goals for the SCI "Dunas de Mira, Gândara and Gafanhas" are as follows:

- to identify the services provided to people by the ecosystems of the study area;
- to assess the conservation status of the forest ecosystems of the Site of Community importance "Dunas de Mira, Gândara and Gafanhas";
- to map the ecosystems of the Site, in accordance with European and national standards and specifications;
- to have a grasp of the value of natural capital, that is, of the value resulting from ecosystem services, including services having to do with use, appropriation, extraction, and also non-use, or simple existence.
- to carry out cost-benefit analyses that are more compatible with a logic of interactive and dynamic relationship between, on the one hand, the tangible/measurable dimensions of reality and, on the other, the intangible ones, which are inherently difficult to measure, assess, and assign value;
- to assess the development of ecosystems and their services in the study area up to the year 2050 (in accordance with the EU Biodiversity Strategy);
- to impress the importance of ecosystems and biodiversity upon citizens and decision-makers;
- to promote sustainability of the main economic activities related to the exploration and use of natural resources in the study area;
- to help ensure well-functioning ecosystem services and functions.

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2. Materials and Methods

The methodological proposal for the Mapping and Assessment of Ecosystems and their Services (Figure 4) is an adaptation of the model put forth by Maes *et al.* (2013) [3]. It entails a chain of tasks, methods and techniques associated with the acquisition of data for map production, which in turn entails, for instance:

- to map ecosystems at a scale of 1/25000, by a direct correspondence between the classes of land use and land cover (COS17[2])and EUNIS level III classes;
- to update the mapping of the ecosystems identified in the study area for the year 2017, by using GIS geoprocessing of high-resolution imaging obtained by the Sentinel 2-A (European satellite of the European Space Agency's Copernicus Program), and by using the methodology established in the portuguese Territorial General Directorate (COS07);
- to design of a model for assessing the state of ecosystems;
- to assess ecosystem services according to the CICES V4.3 classification;
- to use spatial modeling and develop future (predictive) scenarios in a GIS environment.

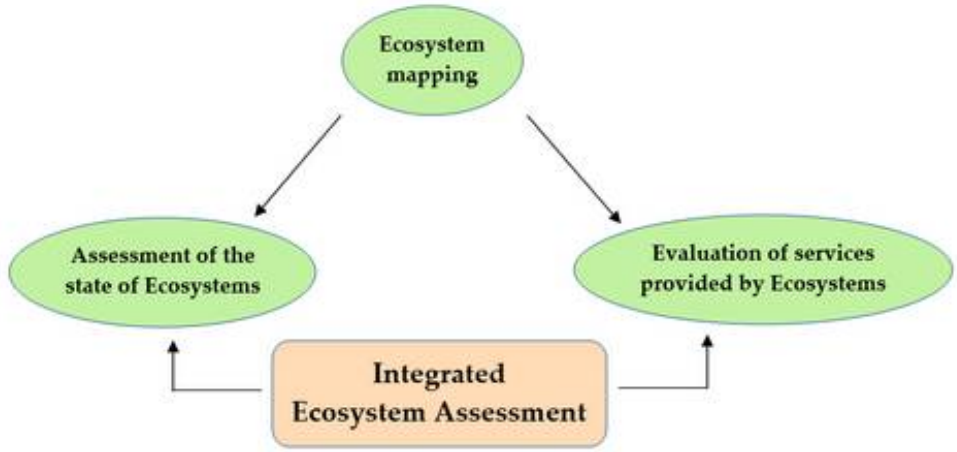

Figure 4- Integrating Ecosystem Assessment - Simplified scheme.

2.1. Classification models - methodological heritage; a brief synapse of the state of the art

For Maes *et al.*, (2013) [3], the Common International Classification of Ecosystem Services offers a structure that links with the framework of the UN System of Environmental-Economic Accounts. "(…) in the CICES system, services are either provided by living organisms (biota) or by a combination of living organisms and abiotic processes". The use of common terminology in mapping, assessment and accounting contributes to the shaping of an integrated, holistic perspective. The need to bring together ecosystem mapping, environmental accounting, economic increasing and, also, the potential benefits to be obtained, has led to the creation of a useful platform for characterizing and assessing ecosystem services [3]. These services are sometimes viewed "as arising from living organisms (biota) or the interaction of biotic and abiotic processes and refer specifically to the 'final' outputs or products from ecological systems" – in a word, what we directly consume, use or enjoy.

This approach rests on a five-level hierarchical structure (section, division, group, class, and class type), which is in conformity with the proposal of Maes *et al.*, (2013) [3], in particular, when they refer that "The more detailed class types makes the classification more 'user-friendly' and provides greater clarification on what ecosystem services are included within each class. Using a

[2] The portuguese acronym for "Land Occupancy Map"; it is from the update to 2017 that one arrives at the cartography of the ecosystems.

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five-level hierarchical structure is in line with United Nations Statistical Division (UNSD) best practice guidance as it allows the five-level structure to be used for ecosystem mapping and assessment, while the first four levels can be employed for ecosystem accounting without reducing the utility of the classification for different users."

The CICES classification model establishes a hierarchical structure whose highest level is divided into three classes [29]:

- Provisioning services: services derived from natural, semi-natural, agricultural, forest, marine, river, and other ecosystems, including foodstuffs, raw materials such as wood, wild products, or water, and energy materials. Their availability depends to a great extent on the supporting and regulating services;
- Regulating and maintenance services: ecological services provided by the ecosystems and the resulting impacts, such as the regulation of erosion, resistance to fire, pollination, primary production (photosynthesis), soil formation, water and nutrient cycling;
- Cultural services: having to do with spiritual or intellectual and non-consumptive uses, ecosystem services sites that where humans interacted (and still interact) with each other and with nature over centuries[3;] they include recreation and leisure, aesthetic benefits, physical and spiritual well-being, a sense of belonging and, also, educational, heritage, and even religious services.

According to (Maes *et al.*, 2016) [31], in the EU, the Mapping and Assessment of Ecosystems and their Services (MAES) is seen as a key action for the advancement of biodiversity objectives and, also, to inform the development and implementation of related policies on water, climate, agriculture, forest, marine and regional planning. Having covered some of the most influential currents of thought relating to the mapping of ecosystem services, we should now point out the fact that in every single case the explicit goals will not be achieved with mapping exercises alone, but rather – as argued by Maes *et al.*, (2013) [3] – by combining digital mapping with an assessment of ecosystem services supply and demand (including the spatial interactions between those systems, based on rigorous, thorough fieldwork).

Ecosystem mapping consists in the spatial delimitation of ecosystems according to predefined typologies and taking into due account the scale and objectives of the mapping exercise in question [32]. As stated by Maes *et al.* (2013, 2014) [3, 33], the typologies to be adopted for the mapping of ecosystems should, wherever possible, be the result of a direct correspondence between the Corine Land Cover (CLC) classes and the habitat types provided for by the European Nature Information System (EUNIS). Banko *et al.* (2013) [34], use level 2 of the EUNIS classification as the foundation for a mapping that follows a system of "cascading" habitats, from Levels 1 (most general) through 6 (most detailed). Ecosystem services maps may represent a variety of biophysical dimensions, with each dimension making use of a specific approach and data type. As a result, the mapping of each dimension produces a different outcome [35].

3. Results

The first approach aimed at mapping ecosystem services in the area under study focused on the updating of the land use map (COS), under the technical and methodological specifications previously defined for COS2007 and COS 2010, updated for the year 2017. This approach was implemented using a combination of data and tasks, including photo-interpretation of aerial images (ortho-photomaps of 2005, 2010 and 2015), satellite images (Sentinel 2 - COPERNICUS Program, and GOOGLE EARTH - satellite and street view), cartography of burned areas and the analysis of "photospots" containing the data of the National Forest Inventory in its latest version (both provided by ICNF-Portugal) and also the analysis of geographic data related to the licensing of

[3] "Anthropocentric values can be expressed in diverse ways. They can be material or non-material, can be experienced in a non-consumptive way, or consumed; and they can be expressed from spiritual inspiration to market value. They also include existential value (the satisfaction obtained from knowing that nature continues to be there) and future-oriented values" [30].

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plantations of forest species of the portuguese Legal Regime of Afforestation and Reforestation Actions (RJAAR)[4]. The data geoprocessing tasks and image segmentation were developed using QGIS software and IMPACT Toolbox software (developed by the Joint Research Center (JRC) of the European Union), respectively. A Land Use and Occupation Map was obtained for the SCI "Dunas de Mira, Gândara and Gafanhas" which can be characterized by the following parameters:

- minimum map unit (MMU): 1ha;
- minimum distance between lines: 20m;
- 61 classes at level 5;
- 26 classes at level 3;
- 5 classes at level 1;
- overall accuracy: 93.20%.

The final map (Figure 5) was obtained based on the establishment of a direct relationship between COS level 5 and EUNIS level 3 typologies, with 31 ecosystems, including the built environment (J - Constructed, industrial and other artificial habitats). The attribution of the class was refined using auxiliary information, namely that obtained from the mapping of natural habitats (Natura 2000 network, 1/100 000 scale, IFN06 data), from 2015 ortho-photomaps and from an accurate work which allows us to adjust and, where possible, validate the information processed in the office.

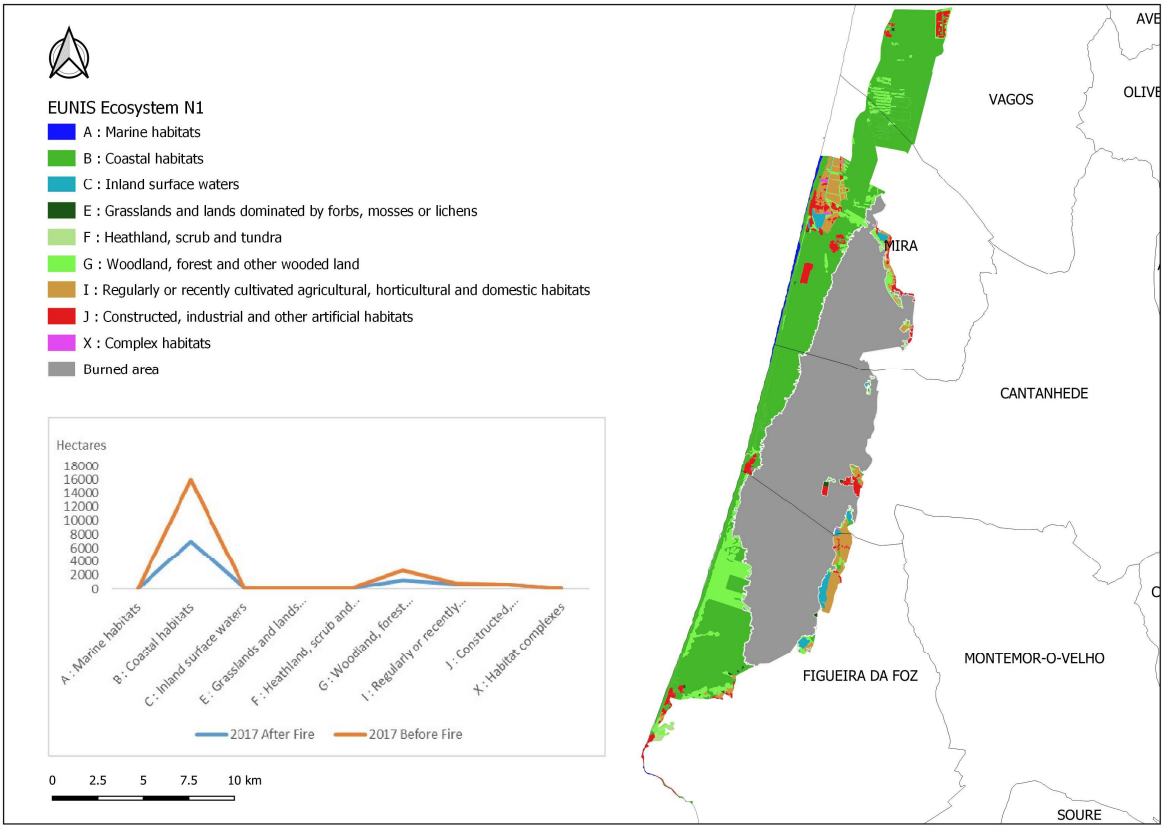

Figure 5- Ecosystems of the SCI "Dunas de Mira, Gândara e Gafanhas" (EUNIS level 1), after the forest fires (october, 2017).

4. Discussion

A first reading of the results shown in Figure 5, allowed us to verify that, before the forest fire (october, 2017), the ecosystems with the greatest expression were those of type B - Coastal Habitats - representing 77,9% (16008,24ha) of the total area, which include the large formations of pine forests. We also highlight the importance of type G - Woodland forest and other wooded land

[4] The legal regime applicable to afforestation and reforestation actions is regulated by Decree-Law no. 96/2013, of July 19, in force since October 17, 2013, amended and republished by Law no. 77/2017, of August 17th.

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type ecosystems, with less expression, which include riparian galleries, eucalyptus plantations and acacials, with an area of 868,92 ha, corresponding to 13,2 % of total area. After the fire, these two categories of ecosystems were reduced to less than half their area, 7015,61 ha and 1253,5 ha, respectively. The area occupied by agricultural ecosystems (I - Regularly or recently cultivated agricultural, horticultural and domestic habitats) corresponds to about 868,92 (4.2%) and that of the C - Inland surface waters, about of 209,28ha (1%). Another finding is that the sum of the areas of other ecosystems (A - Marine habitats; E - Grasslands and lands dominated by forbs, mosses or lichens, F - Heathland, scrub and tundra and X - Complex Habitats) is less than 181,8 ha, representing a total area of less than 1%. After the fire, in the case of type I ecosystems, there was an area loss of 122,13 ha, whereas in the set of ecosystems type A, E, F and X, the loss of area was very little expressive.

Finally, we highlight the importance of the fire of October 15, 2017, in the geomorphodynamics of the SCI ecosystems "Dunas de Mira, Gândara and Gafanhas" due to the vast arid extension - 10582,12ha, that is, 52% of the total area of the SIC. This event has led to the loss of many ecosystem services in the region under study, in terms of decreasing in their value and diversity of their services. The mapping of classified ecosystems and the assessment of the size and the impacts of the burned areas allows estimating loss values for each class of ecosystems. This should be taken in account in the implementation of policy measures to restore ecosystems and their services.

The philosophy followed in this methodological approach for the purposes of valuing services and mapping the ecosystems of the Site of Community Importance "Dunas de Mira, Gândara e Gafanhas", applied in accordance with the national and community directives, allows to conclude that they (both) key strategies to improve land management by valuing the importance of ecosystems benefits as a public good that everyone must protect and preserve. This methodological essay, which focused more on the mapping component than on the assessment component, revealed some difficulties in the compatibility of terms, concepts and the classification of ecosystems with different functionalities, which requires the implementation of an interoperable reasoning between methodologies and models (MAES, CICES, EUNIS) and, in the Portuguese case, a strict articulation between pre-existing cartographic information (CLC, COS 2007 and COS 2010) and the procedures for updating to the most recent version of COS (2017).

The interaction between nature and human activities is, in fact, a relationship very difficult to manage, especially if we consider the occurrence of forest fires (mostly of anthropic origin) which, in the area under study, presents a history of repeated events of destruction of ecosystems. The most recent episode of this context, which led us to retreat to October 2017, resulted in a considerable loss of biomass and of the respective bio-services, namely those produced by forest ecosystems such as "B - Coastal Habitats", considering that more than 50% of the ICS area was consumed by the flames. Despite the above mentioned difficulties, we can conclude that the provision of ecosystem mapping and assessment of their services allows, every moment, quantifying the absolute (or relative - percentage) importance of each of them and how they evolve over time, which means that a new culture of prevention can be implemented to the detriment of a reactive culture that has become the rule in terms of human intervention in the protection and management of ecosystems and their services. In this sense, the awareness that a mono-specific occupation (as in the case of wild pine trees in the study area which represented about 77% of B - Coastal Habitats) reflects a political practice for the management of forests that has long since ceased to be recommended. The commitment to bio-diversity and the recovery of the forest area by typically mediterranean species is a recommendation that is intended to be expressed in this study because it is one of the best guarantees in terms of preserving the quality of forest ecosystems and their services.

5. Conclusion

The Site of Community importance “Dunas de Mira, Gândara and Gafanhas” is comprised mainly of the type of ecosystems found in sandy formations in a Mediterranean coastal context,

where thirty-one ecosystems, including what corresponds to the built environment (J - Constructed, industrial and other artificial habitats, according to the EUNIS classification), have been identified as bearing a direct correspondence between the COS07 and EUNIS classes.

The work currently under way aimed to identify and assign value to the ecosystem services and at the same time to assess their conservation status. Of the total ecosystems that were mapped, 90% are forest areas, mostly of Pinus pinaster formations. After the forest fire of 2017, which consumed more than 50% of the SCI area, there were enormous losses in the natural capital of this area, with a significant reduction in ecosystem services, still not quantified. It is now important to implement measures aimed at ecosystems restoring processes, particularly at the level of regulation and maintenance of the services most affected by these fires. For this purpose, modern GIS technologies can be used, from the data acquisition phase to the production of cartographic layouts.

This approach is based on strong and coherent methodological proposals for the ecosystems assessment and mapping [3, 33] is intuitive and leaves room and confidence for the researcher to test, adapt and innovate, even if a number of adaptations, both conceptual and methodological, need to be made in order to reach a GIS-based consistent methodological proposal in order to ensure the proper management of ecosystems and their services.

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