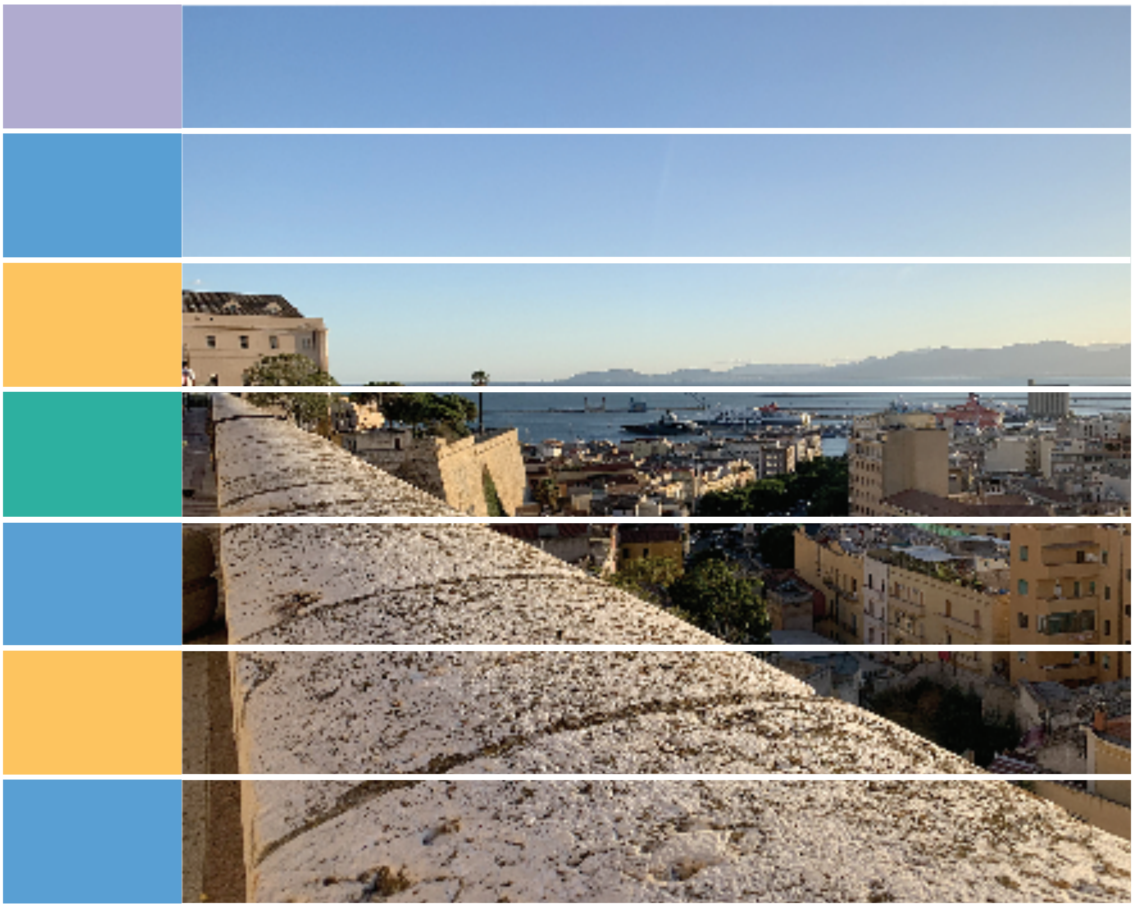
Carmela Gargiulo Corrado Zoppi
Editors

Planning, Nature and Ecosystem Services



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Smart City, Urban Planning for a Sustainable Future

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Carmela Gargiulo   Corrado Zoppi

Editors

Planning, Nature and Ecosystem Services

INPUT aCAdemy 2019

Conference proceedings

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La cooperazione al cuore del Mediterraneo

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This book collects the papers presented at INPUT aCAdemy 2019, a special edition of the INPUT Conference hosted by the Department of Civil and Environmental Engineering, and Architecture (DICAAR) of the University of Cagliari.

INPUT aCAdemy Conference will focus on contemporary planning issues with particular attention to ecosystem services, green and blue infrastructure and governance and management of Natura 2000 sites and coastal marine areas.

INPUT aCAdemy 2019 is organized within the GIREPAM Project (Integrated Management of Ecological Networks through Parks and Marine Areas), co-funded by the European Regional Development Fund (ERDF) in relation to the 2014-2020 Interreg Italy – France (Maritime) Programme.

INPUT aCAdemy 2019 is supported by Società Italiana degli Urbanisti (SIU, the Italian Society of Spatial Planners), Istituto Nazionale di Urbanistica (INU, the Italian National Institute of Urban Planning), UrbIng Ricerca Scientifica (the Association of Spatial Planning Scholars of the Italian Schools of Engineering) and Ordine degli Ingegneri di Cagliari (OIC, Professional Association of Engineers of Cagliari).

This book is the most recent scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT aCAdemy 2019 Conference. In detail, this publication, including 92 papers grouped in 11 sessions, for a total of 1056 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Carmen Guida;
- Rosa Morosini;
- Floriana Zucaro.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa
Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
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FROM ECOSYSTEMS TO ECOSYSTEM SERVICES

A SPATIAL METHODOLOGY APPLIED TO A CASE STUDY IN SARDINIA

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ABSTRACT

Ecosystem services (ES) evaluation is the most recommended approach to assess and monitor environmental health and quality of human life. A key role to ensure provision of ecosystem benefits is played by protected areas and nature conservation projects worldwide. Natural capital accounting includes ES evaluation in sustainable land management and planning, setting the challenge to monitor ES over time and to update governance tools considering ES flows. The MAES initiative by the European Environmental Agency suggests ecosystems as the proper land units to evaluate, map and monitor related ES. Ecological Land Classification methodology was applied to obtain Asinara island (Sardinia, Italy) Ecosystem Map within the activities of GIREPAM project (INTERREG Program 2014-2020), aimed at integrating management policies in marine protected areas and parks governance. An ES inventory was also implemented, among others, through expert opinion survey, and carbon sequestration potential was estimated and mapped. Preliminary results of potential ES all over Asinara island territory and carbon sequestration mapping are presented, representing important tools for Asinara National Park future management planning and governance.

KEYWORDS
Ecosystem Services; Ecological Land Unit; Carbon Sequestration; Asinara National Park

* The other authors are: Sabrina Lai, Andrea Motroni.

1 INTRODUCTION

The GIREPAM project, funded by the 2014-2020 INTERREG V-A Italy-France Maritime Programme (http://interreg-maritime.eu/web/girepam), aims at sharing a Mediterranean cross-border strategy for the integrated management of marine-coastal areas, focusing on biodiversity protection and ecosystem services maintenance in protected areas and Natura 2000 sites. Among others, methodological tools have been proposed in order to assess, map and evaluate ecosystem services (ES) according to Systems of Environmental and Economic Accounting (SEEA).

In order to support Systems of National Accounting, the European Environmental Agency (EEA) developed CICES – the Common International Classification of ES (Haynes-Yang & Potschin, 2017).

ES are clustered in four categories according to the Millennium Ecosystem Assessment (MEA, 2003): provisioning ("all nutritional, non-nutritional material and energetic outputs from living systems as well as abiotic outputs - including water-"), regulating ("all the ways in which living organisms can mediate or moderate the environment that affects human health, safety or comfort, together with abiotic equivalents"), cultural ("all the non-material, and normally non-rival and non-consumptive, outputs of ecosystems - biotic and abiotic - that affect physical and mental states of people"), supporting ("those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation). The latter, however, is not regarded as a group in the CICES taxonomy, which regards as ES only those that are demanded and used by humans.

Natural capital can also be defined in spatially-explicit ways, through geographic instruments which may help to analyze, assess, monitor and map homogeneous ecological patterns together with related services (MAES, 2013; MAES, 2014).

The European initiative for Mapping and Assessment of Ecosystems and their Services (MAES) by EEA, aims at (i) mapping ecosystem, (ii) evaluating their conservation status; (iii) assessing ES. In order to implement the 2020 EU Biodiversity Strategy, member states and European Institutions implemented an Ecosystem map (MAES, 2016; Erhard et al., 2017) at the continental level, based on Corine land cover (CLC), which clusters main terrestrial ecosystem types, transitional waters and coastal areas in seven CLC classes.

European Nature Information System (EUNIS) was integrated with the CLC one, which led to better defining and characterizing current ecosystem conditions, merging "ecosystem" and "habitat" concepts, thus finding key indicators for mapping and assessing ecosystem conditions (MAES, 2018). Several case studies have been recorded and published in the EEA portal (https://biodiversity.europa.eu/maes/maes-digital-atlas) in order to implement National

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Ecosystem Maps. In Italy, recent case studies in ecosystem mapping are based on the integration of Ecological Land units (MAES sensu) with the Potential Vegetation series (Blasi et al., 2014) as ecosystem quality facies; for local assessment (at regional, sub-regional, little island scales), a first critical issue is represented by properly scaled data in order to implement local land and nature conservation management policies (Blasi et al., 2017).
The objective of this work is to define an Ecosystem map for Asinara island, applying the Ecological Land Unit (ELU) approach (Smiraglia et al., 2013) through spatial and reasoned overlay of abiotic Land Facets and land cover maps.
Related potential ES, with particular reference to carbon stock map, are here presented as preliminary results of the GIREPAM project for Asinara National Park.

2 CASE STUDY

Asinara island is 50 km2 in size and it extends from South-West to North-East to the North of Sardinia, Italy (Fig. 1). The geology of the island is characterized by metamorphic rocks in the north and granitic ones in the south. Asinara presents high cliffs on the western side, and smoother sandy profiles in the eastern side facing Italy's main land. Mean annual rainfall amounts to 480 mm, average of annual temperature approximately being of 18°C (Carboni et al., 2015). Following Rivas-Martinez et al.'s (2011) approach, Canu et al. (2014) described six isobioclimates for the island. More than 50% of the island is characterized by Upper thermomediterranean, upper dry, euoceanic strong, while 31% by Lower mesomediterranean, lower subhumid, euoceanic strong. 8% of total territory presents an Upper thermomediterranean, upper dry, semihyperoceanic weak bioclimate. Only 6,5% of total land is characterized by Lower mesomediterranean, lower subhumid, euoceanic strong. The island vegetation is characterized by typical Mediterranean maquis with some more degraded areas. Endemic flora has been described by Bocchieri and Filigheddu (2008) and explored exhaustively by Pisanu et al. (2014) and Drissen et al. (2019). Populated by a rural community until expulsion in 1885, the environment of the island was next largely affected by the presence of an agricultural penal colony (Forteleoni & Gazale, 2008; Gutierrez et al., 1998). The subsequent abandonment of farming activities previously carried out by prisoners in the early '70s led to land degradation due to overgrazing by cattle and other rewilded animals and frequent forest fires across the island, as summarized also by Mantilla-Contreras et al. (2018). In 1997 Asinara National Park was established turning the island into a great important biodiversity hotspot, due to the presence of several rare, threatened, endemic marine and terrestrial habitat and species.

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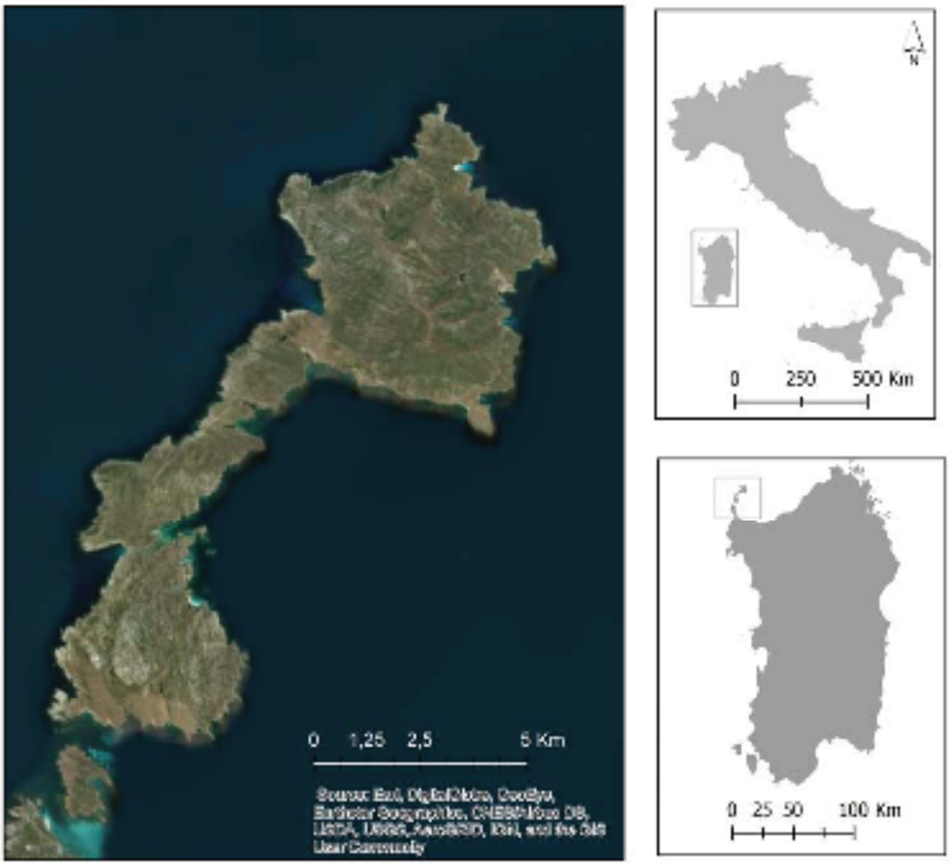

Fig. 1 Asinara island

3 ECOSYSTEM MAP: MATERIALS AND METHODS

Asinara's ecosystem map was obtained following the "Ecological Land Classification" (ELC) framework by Smiraglia et al. (2013), who identify ecological homogeneous areas of abiotic drivers, based on land facets which greatly influence biotic distribution such as vegetation series potential and ecological processes (Blasi et al., 2014; Blasi et al., 2017). Bioclimatic, lithology and landform geographic information layers were overlaid in order to obtain a Land Facet Map (LFM). Asinara climate has been classified using Sardinia Bioclimatic Map (Canu et al., 2014), while lithological map has been produced at a 1:10,000 scale. Phytoclimatic heterogeneity depends not only on bioclimate and lithology but strongly on the wide altitudinal gradient of the island, which can reach quite high altitudes (Punta Scomunica, 408 m a.s.l, in the northern part, and Punta Maestra Fornelli, 265 m a.s.l.) within a short distance from the

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coast. Landform map has been implemented using a Digital Elevation Model for Sardinia island (resolution 10m x 10m), based on Topographic Position Index based on a 10-class landform classification. A Land Facet Map of 44 hierarchical classes was obtained (Fig. 2) and combined with an updated land use map of Asinara (Fig. 3) in order to produce an Ecosystem Map with 188 Ecological Land Units.

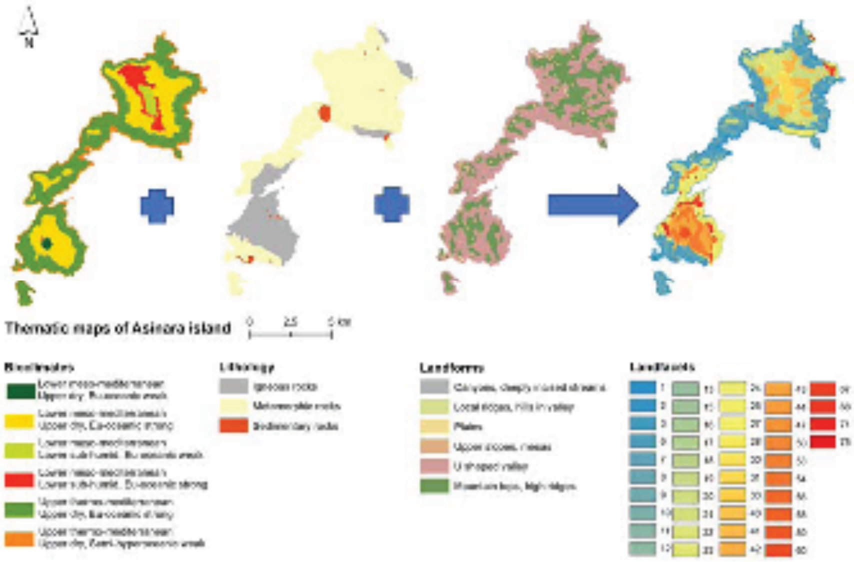

Fig. 2 Bioclimates, lithology, landform and land facet map of Asinara

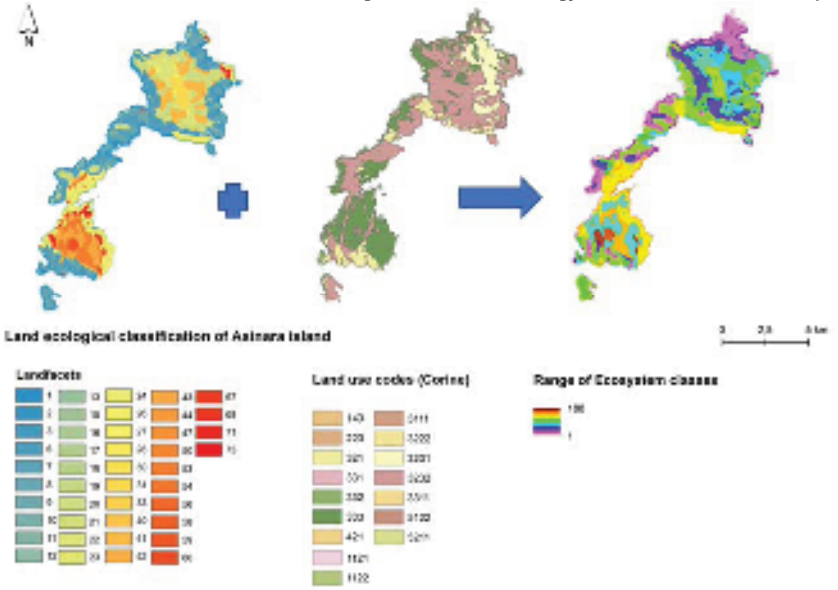

Fig. 3 From land facet and land use combination to the Ecosystem Map of Asinara

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4 PRELIMINARY RESULTS

4.1 POTENTIAL ECOSYSTEM SERVICES

Qualitative evaluation of Potential ES for Asinara island was carried out through an expert opinion questionnaire submitted to a group of Asinara National Park members, nature conservation academics and socioecological experts.

	SECTION	CLASS
Biotic	Cultural	Characteristics of living systems that enable education and training
		Characteristics of living systems that enable aesthetic experiences
		Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge
		Characteristics of living systems that are resonant in terms of culture or heritage
	Regulation & Maintenance	Elements of living systems that have symbolic meaning
		Elements of living systems used for entertainment or representation
		Characteristics or features of living systems that have an existence value
		Decomposition and fixing processes and their effect on soil quality
		Seed dispersal
		Bio-remediation by micro-organisms, algae, plants, and animals
		Disease control
		Visual screening
		Control of erosion rates
		Fire protection
		Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
		Regulation of temperature and humidity, including ventilation and transpiration
		Regulation of the chemical condition of freshwaters by living processes
		Maintaining nursery populations and habitats (including gene pool protection)
		Pollination (or 'gamete' dispersal in a marine context)
	Pro visio ning	Seeds, spores and other plant materials collected for maintaining or establishing a population
		Animal material collected for the purposes of maintaining or establishing a population

Tab. 1 Biotic classes of CICES (ver.5.1) as perceived by expert opinion as Asinara potential ecosystem services

Firstly, experts were asked to identify CICES ES classes for Asinara ecosystems, following the same approach used in other studies of ES assessment of Protected Areas (Gaglioppa &

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Marino, 2016; Manolaki & Vogiatzakis, 2017). Moreover, a value ranging 0 to 5 for each ES class was assigned. A participatory approach and discussion with National Park entrepreneurs was carried out in order to assess their perception of real and potential ES, and results were mapped in order to make them available to further support future Asinara Park management policies. In the following table a list of ES evaluated by experts is shown. 33 CICES Classes for Asinara, out of the 65 listed by Haynes-Yang and Potschin (2017), were identified and valued (Tab. 1; Tab. 2). Biotic ES are those perceived as most important for the island, provisioning and maintenance classes are the most redundant ones but both cultural biotic and abiotic ES represent an interesting field of natural protected values to be explored, analyzed, conserved.

4.2 CARBON STOCK POTENTIAL

Carbon (C) monitoring is important to quantify carbon dioxide and C compounds amount produced by human activities. In C balance accountability, incrementing carbon sink capacity of terrestrial pools is crucial at the local, regional and global scale, to accomplish obligations stemming from the Kyoto protocol.

Among ES, C sequestration recorded in a given time period and referred to a specific land use/land cover change, has become not only a key indicator (MAES, 2018) to track conservation status of ecosystems but also a climate change policy tool for adaptation and mitigation strategies.

A map of Asinara carbon stock as derived from ELU ecosystem classification is presented, using C data available in scientific literature for comparable land uses. Forest carbon estimation follows the approach of the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), which identifies "gain-loss" and "stock-difference" methods, designed respectively to estimate changes in carbon content and in biomass growth in a fixed time interval (e.g. two forest inventories). In this study, 2018 C stock is estimated to be the yearly mean value of C stock in Asinara island.

C stock was evaluated in 4 different pools of living vegetation: *above ground biomass* (ABGB), *below ground biomass* (BGB), *litter* and *Soil Organic Carbon* (SOC), following IPCC (2006). In order to estimate biomass carbon content, IPCC suggests considering 0.5 g of C per 1 g/cm^3 of biomass volume (dry weight), expressed in tons of C/hectare when estimated values are reported in a map. Land uses related to artificial surfaces, wetlands, bare rocks, open spaces with no vegetation, beaches are not considered. Olive groves land use class, due to the small size and restricted number of plants, has been treated as an evolution of Mediterranean maquis.

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	SECTION	CLASS
Abiotic	Cultural	Natural, abiotic characteristics of nature that enable intellectual interactions
		Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions
		Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions
		Natural, abiotic characteristics or features of nature that have either an existence, option or bequest value
	Regulation & Maintenance	Dilution by freshwater and marine ecosystems
		Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)
		Maintenance and regulation by inorganic natural chemical and physical processes
		Mediation of nuisances by abiotic structures or processes
	Provisioning	Wind energy
		Solar energy
		Ground (and subsurface) water for drinking
		Ground water (and subsurface) used as a material (non-drinking purposes)

Tab. 2 Abiotic classes of CICES (ver.5.1) as perceived by expert opinion as Asinara potential ecosystem services

Above ground biomass C potential for forest (*Quercus ilex*) has been evaluated considering tree phytomass allometric equation by Tabacchi et al. (2011), taking as tree variables for biomass: a) mean Diameter Breast Height (DBH) 20 cm; b) mean plant Height 8 m; c) mean density of 150 trees/Ha. Above ground biomasses C for Mediterranean maquis, sparsely vegetation areas, moors and shrublands have been evaluated as vegetation types at different recolonization degree (Sirca et al., 2016). Sclerophyllus vegetation (garrigue, sparsely vegetated areas and 5-40% of bare soil) was here considered as *Cistus monspeliensis* dominant land cover (*sensu* Stadmann, 2016*).* Since *Cistus monspeliensis* represents 33% of total cover of low recolonization degree, only this portion of Mediterranean maquis C stock was considered. In order to determine Natural grasslands C stock, 2017 Agristat data for unproductive grassland in North Sardinia were used (Agri.istat.it).

Below ground biomass (BGB) has been estimated using the Root/Shoot coefficient ratio applied to Above ground biomass C (ABGB) amount, referring to *Quercus ilex* (Hildell, Candell, 1985), to Mediterranean Maquis and *Cistus monspeliensis* (Bianchi et al., 2005) values. For natural grassland another Root/Shoot coefficient for open grasslands in temperate climates was used, as suggested by IPCC (2006).

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In order to estimate Soil Organic Carbon (SOC), the 2005 National Inventory of Forest Carbon data (Gasparini et al., 2013) has been used for *Quercus ilex* forest, while local data for bare soils or areas temporarily uncovered by vegetation have been applied to the other categories. Zero value in SOC has been assigned to natural grasslands. For Litter data, weighted C content data related to areas at different recolonization degree were found in Sirca et al. (2016). Data for each pool are presented in Tab. 3.

LAND USE	ABGB (tons C/ha)	BGB (tons C/ha)	LITTER (tons C/ha)	SOC (tons C/ha)
Forest (*Quercus ilex* woods)	15	7.5	2.8	2.4
Mediterranean maquis	24.02	25.23	1.5	19.88
Garrigue	2.25	1.14	1.5	6.99
Sparsely vegetation areas	7.04	7.39	1.5	21.18
Natural grasslands	1.65	4.62	0	0

Tab. 3 Mean of potential C stock per hectare in main land uses of Asinara island

5 DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The GIS approach here presented, and the resulting high-resolution Ecosystem Map, represents an innovative tool for land management plans and policies, due to spatial resolution and the lack of data at the local scale.

ELC allowed to classify ecosystems at the local scale using the Asinara island as a case study. Potential ES evaluation and mapping was possible using CICES classification potential ES classes. Only C stock was estimated for the territory of Asinara National Park deriving data and information from the literature. Data show that, in our case study, Mediterranean maquis contributes to C storages more than the remaining land covers. Further investigation on other ES will be useful to Asinara National Park administration for land use planning in mid- and long-term scenarios, hence supporting land management policies, such as restoration of natural vegetation series and habitats.

Experts' opinions offered a preliminary assessment of potential ES in the island, and the perceived weakness/strength among different ES classes was recorded. A more advanced and thorough analysis of preliminary results and the implementation of participatory approaches involving a wider target group of Asinara end-users will help build a more complete inventory of ES profile. Cultural features (archaeological, historical, spiritual, etc.) have not been taken into account at this level of investigation but they will be considered particularly if different ES scenarios might lead to conflicting goals and policies.

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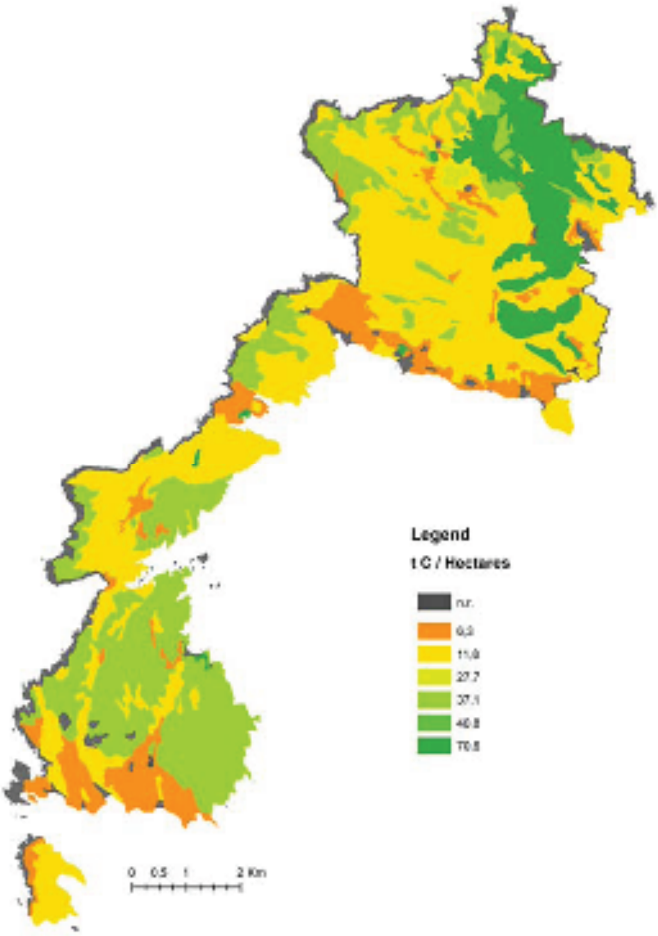

Fig. 4 Carbon stock potential in the Asinara island

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