Antonio Leone Carmela Gargiulo
Editors

Environmental and territorial modelling for planning and design

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Scuola Politecnica e delle Scienze di Base

Smart City, Urban Planning for a Sustainable Future

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Environmental and territorial modelling for planning and design editors Antonio Leone, Carmela Gargiulo - Napoli: FedOAPress. 2018. - (Smart City, Urban Planning for a Sustainable Future. 4).

Web link:
http://www.fedoabooks.unina.it

ISBN: 978-88-6887-048-5
DOI: 10.6093/978-88-6887-048-5

Selection and double blind review under responsibility of Conference Committee

Università degli Studi di Napoli Federico II
Centro di Ateneo per le Biblioteche "Roberto Pettorino"
Piazza Bellini 59-60 - 80138 Napoli, Italy
http://www.fedoapress.unina.it

Published in Italy

Cover and graphic project: TeMA*LAB*

This book collects the papers presented at the 10th International Conference INPUT 2018 which will take place in Viterbo from 5th to 8th September. The Conferences pursues multiple objectives with a holistic, boundary-less character to face the complexity of today socio-ecological systems following a systemic approach aimed to problem solving. In particular, the Conference aims to present the state of art of modelling approaches employed in urban and territorial planning in national and international contexts.

This book is the latest 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 2018 Conference and evaluated with a double peer review process by the Scientific Committee of the Conference. In detail, this publication, including 63 papers grouped in 11 sessions, for a total of 704 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;
- Rosa Anna La Rocca;
- Rosa Morosini;
- Maria Rosa Tremiterra.

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
Published by FedOAPress - Federico II Open Access University Press

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INTRODUCTION

Between 5th and 8th September 2018 the tenth edition of the INPUT conference took place in Viterbo, guests of the beautiful setting of the University of Tuscia and its DAFNE Department.
INPUT is managed by an informal group of Italian academic researchers working in many fields related to the exploitation of informatics in planning.
This Tenth Edition pursed multiple objectives with a holistic, boundary-less character, to face the complexity of today socio-ecological systems following a systemic approach aimed to problem solving. In particular, the Conference will aim to present the state of art of modeling approaches employed in urban and territorial planning in national and international contexts.
Moreover, the conference has hosted a Geodesign workshop, by Carl Steinitz (Harvard Graduate School of Design) and Hrishi Ballal (on skype), Tess Canfield, Michele Campagna.
Finally, on the last day of the conference, took place the QGIS hackfest, in which over 20 free software developers from all over Italy discussed the latest news and updates from the QGIS network.
The acronym INPUT was born as INformatics for Urban and Regional Planning. In the transition to graphics, unintentionally, the first term was transformed into "Innovation", with a fine example of serendipity, in which a small mistake turns into something new and intriguing. The opportunity is taken to propose to the organizers and the scientific committee of the next appointment to formalize this change of the acronym.
This 10th edition was focused on Environmental and Territorial Modeling for planning and design. It has been considered a fundamental theme, especially in relation to the issue of environmental sustainability, which requires a rigorous and in-depth analysis of processes, a theme which can be satisfied by the territorial information systems and, above all, by modeling simulation of processes.
In this topic, models are useful with the managerial approach, to highlight the many aspects of complex city and landscape systems. In consequence, their use must be deeply critical, not for rigid forecasts, but as an aid to the management decisions of complex systems.

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

SPREADING GREEN INFRASTRUCTURE-RELATED BENEFITS

A STUDY CONCERNING SARDINIA, ITALY

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How to cite item in APA format:
Lai, S., Leone, F., & Zoppi, C., (2018). Spreading green infrastructure-related benefits. A study concerning Sardinia, Italy.
In A. Leone & C. Gargiulo (Eds.), *Environmental and territorial modelling for planning and design.*
(pp.569-576). Naples: FedOAPress. ISBN: 978-88-6887-048-5, doi: 10.6093/978-88-6887-048-5

ABSTRACT

The European Commission defines green infrastructure (GI) as a network having the Natura 2000 sites at its core, able of delivering numerous ecosystem services (ESs), and "strategically planned", emphasizing the role of GI as regards the integration of ecological connectivity and protection of the environment, and ecosystems multifunctionality.
In this study we build upon a methodology applied in a previous study (Lai and Leone, 2017), where a Sardinian regional GI was identified based upon four factors: conservation value, natural value, recreation value and landscape value.
Once a regional GI is identified, we comparatively assess the eligibility of areas located inside and outside protected areas to be part of the regional GI on the basis of the four factors indicated above.
We find that patches located in protected areas are comparatively more eligible to be part of the regional GI than patches located outside only as far as conservation value's spatial distribution is concerned. In the other three cases, the behavioral patterns of patches located inside and outside protected areas are less clear-cut. Policy recommendations coming from the outcomes entail the mitigation of land-taking processes, the enlargement of the Natura 2000 Network, the detailed and analytical identification of landscape goods, and the enhancement of the accessibility to attractive sites.

KEYWORDS

Green Infrastructure; Ecosystem Services; Natura 2000 Network; Environmental Planning

1 INTRODUCTION

The Communication of the European Commission "Green infrastructure: enhancing Europe's natural capital" defines a GI as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue, if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings" (European Commission, 2013). Integrating the identification and management of GIs within planning policies represents a key issue with particular reference to the European Landscape Convention (Liquete et al., 2015). As Hansen and DeFries (2007) argue, planning tools in protected areas aim at building an integrated ecosystem by establishing noteworthy ecological and socio-economic relationships with their neighboring areas. Moreover, according to various authors (Gaston et al., 2006; Ruiz Benito et al., 2010), assessing spatial policies concerning protected areas could improve efficiency and effectiveness of environmental protection measures and of related management measures.

In our view, the identification and planning of a regional GI can be conceived as a significant tool to extend the positive impacts of environmental conservation policies beyond the boundaries of protected areas. Rural areas and urban green spaces are indeed to be included within a regional GI (Spanò et al., 2017; Wickham et al., 2010). Building upon the methodology developed by Lai and Leone (2017), who identify a regional GI in relation to four values conservation value (CONS_V), natural value (NAT_V), recreation value (RECR_V) and landscape value (LANDS_V)), our study aims to assess the suitability of areas to be included in the regional GI based upon the above mentioned four values in case of both unprotected and protected areas. In particular, CONS_V accounts for the presence of habitats of community interest, identified under the provisions of the Directive no. 93/43/EEC, also known as "Habitats Directive". NAT_V takes into account the capacity of biodiversity to provide ecosystem services. RECR_V accounts for the relationships between landscape attractiveness and areas where people spend their leisure time. LANDS_V takes into account the presence of landscape assets as defined by the Italian Code on cultural goods and landscape (Law enacted by decree no. 2004/42). Under this perspective, the definition of a holistic planning approach that integrates the relationships between the regional GI and protected areas can support and strengthen spatial planning policies to enhance the capacity of ecosystems to provide services. This study comprises four sections. The methodological approach is described in the second section. The outcomes are presented in the third section and discussed in the fourth, which also provides final considerations and directions for future research.

2 MATERIALS AND METHODS

Sardinia is an Italian island characterized by a significant presence of protected areas - around 19% of its land mass (Fig. 1). The Sardinian regional administration approved a Regional Landscape Plan (RLP) in 2006; such plan does not provide any reference to a regional GI. In this study, we apply the methodological approach developed by Lai and Leone (2017), where a regional GI is defined and mapped through four values (CONS_V; NAT_V; RECR_V; LANDS_V) that reflect the landscape's multifunctional nature. In particular, CONS_V, calculated following the approach developed in a regional report (CRITERIA & TEMI, 2014a), takes non-null values in areas characterized by the presence of habitats of community interest, and it is computed as follows:

$$CONS\_V=P*(R+T+K)$$

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

where P accounts for the presence of priority habitats listed in the Annex II of the Habitats Directive, R assesses the rarity of each habitat in relation to its occurrences within the Sardinian Natura 2000 standard data forms, T accounts for threats, and K assesses current knowledge on each habitat based on the results of a regional monitoring report (CRITERIA & TEMI, 2014b). CONS_V can take values in the [0-21] interval. NAT_V was computed and mapped through the "Habitat quality" model of the open source software "InVEST". The model requires different input data, such as land use/land cover map, a list of threats to habitats and their spatial distribution, a vector map defining accessibility to sources of degradation, the suitability of each land cover type to be considered as habitat and its sensitivity to each threat, and a half-saturation constant.

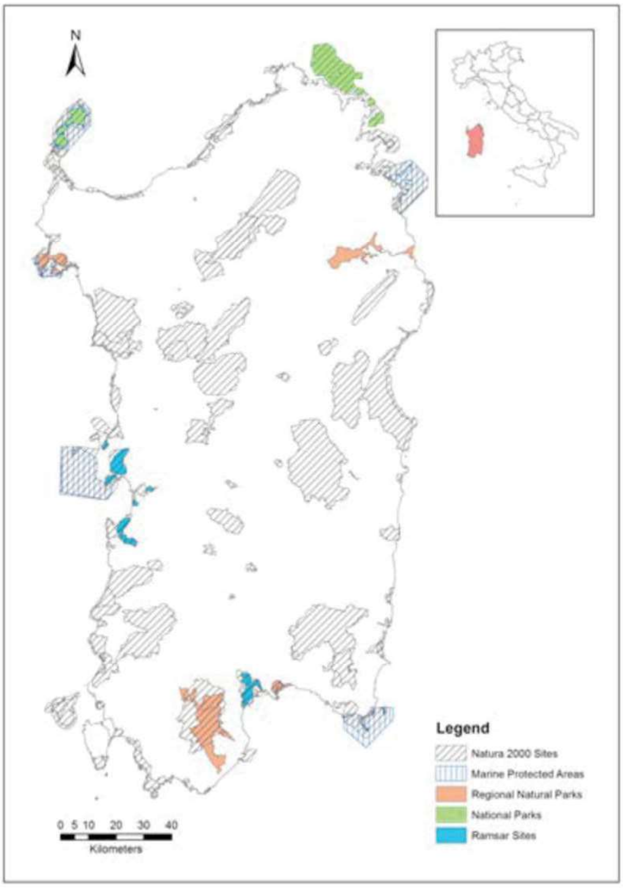

Fig. 1 Study area. Source: own work

RECR_V was computed and mapped through the "Visitation: recreation and tourism" model of InVEST, which, by using data provided by the social media Flickr, in each cell of the study area calculates the total number of pictures uploaded by a single user in a single day between 2010 and 2014. LANDS_V accounts for the significance of landscape assets in relation to the strictness of RLP's rules. All of the four values, normalized in the [0-1] interval, were mapped and summed through GIS techniques. As a result, the total value (TOT_V) can take values within the [0-4] interval. In order to evaluate if and to what extent the four values influence the suitability of areas to be included in a regional GI, within or outside protected areas, we classified the Sardinian land mass into two macro-categories: natural protected areas (consisting of national and regional parks, Natura 2000 sites and Ramsar sites), and the rest of the region (hereinafter,

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

"unprotected areas"). TOT_V values were arranged into tertiles. Moreover, in relation to both protected and unprotected areas, for each tertile of TOT_V, and for each of the four values, we estimated areas taking null values and we calculated their percentage in relation to the total area of the macro-category in the specific tertile and assessed the mean of CONS_V, NAT_V, RECR_V and LANDS_V.

3 RESULTS

Fig. 2 and Tab. 2 provide the results of the analysis. In particular, Fig. 2 shows the spatial distribution of TOT_V on the left and the spatial distribution of each x_V (CONS_V, NAT_V, RECR_V and LANDS_V) on the right.

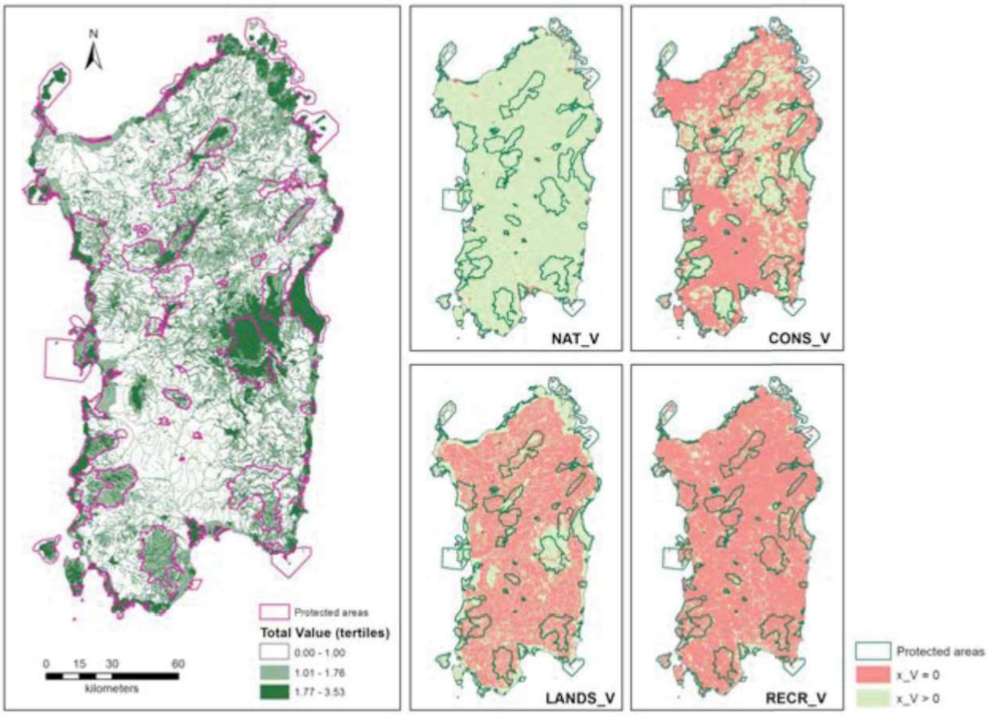

Fig. 2 To the left: Total value (TOT_V), i.e. suitability of each land parcel to be part of a regional GI (tertiles), also showing the boundaries of protected areas. To the right: spatial layout of the four values; superimposed are the boundaries of protected areas. Source: own work

Tab. 2 reports, for each macro-category and for each of the four values in relation to each tertile of the total value, the following indicators: mean value, number of patches taking the null value, percentage of such patches with respect to the total number of patches in the corresponding tertile, total area of patches taking null values and the percentage of these areas with respect to the total area included in the corresponding tertile. Natural protected areas show steadily increasing values of the mean between the first and the third tertiles in the case of CONS_V, RECR_V and LANDS_V, while NAT_V's mean decreases from 0.55 to 0.47, when switching from the first to the second tertiles. The highest percentages (in terms of both number of patches and area) of patches taking null values correspond to LANDS_V and RECR_V in the first and second tertiles, and CONS_V and RECR_V in the third tertile. NAT_V shows a low presence of patches taking null values in terms of number of patches and their percentage, and percentage of areas. This can be clearly observed for the percentage of areas with null values, which equals 2.19%, 2.18% and 0.23% in the first, second and third tertiles, respectively.

ISBN:978-88-6887-048-5
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			CONS_V	NAT_V	RECR_V	LANDS_V
Natural protected areas (467,635.13 ha)	1st tertile: TOT_V = [0 - 1] (94,150.93 ha)	mean	0.13	0.55	0.002	0.11
		no. patches x_V = 0	17,366	4,526	23,944	24,401
		% patches x_V = 0 $^{(*)}$	63.34	16.51	87.34	89.01
		total area x_V = 0 [ha]	87,332.79	2,063.00	89,766.74	93,097.17
		% area x_V = 0 $^{(**)}$	92.76	2.19	95.34	98.88
	2nd tertile: TOT_V =]1 - 1.57] (148,548.90 ha)	mean	0.25	0.47	0.017	0.57
		no. patches x_V = 0	16,661	20,482	24,064	20,825
		% patches x_V = 0 $^{(*)}$	33.99	41.78	49.09	42.48
		total area x_V = 0 [ha]	30,961.17	3,244.88	123,262.52	120,388.14
		% area x_V = 0 $^{(**)}$	20.84	2.18	82.98	81.04
	3rd tertile: TOT_V =]1.57 - 3.53] (224,935.30 ha)	mean	0.34	0.89	0.024	0.95
		no. patches x_V = 0	21,452	2,102	44,796	2,741
		% patches x_V = 0 $^{(*)}$	24.41	2.39	50.98	3.12
		total area x_V = 0 [ha]	45,805.20	509.24	160,293.70	9,970.11
		% area x_V = 0 $^{(**)}$	20.36	0.23	71.26	4.43
Unprotected areas (1,940,665.60 ha)	1st tertile: TOT_V = [0 - 1] (1,015,579.00 ha)	mean	0.08	0.53	0.005	0.05
		no. patches x_V = 0	132,144	22,824	129,865	157,793
		% patches x_V = 0 $^{(*)}$	79.62	13.75	78.25	95.08
		total area x_V = 0 [ha]	963,608.81	50,825.56	940,178.56	999,186.97
		% area x_V = 0 $^{(**)}$	94.88	5.00	92.58	98.39
	2nd tertile: TOT_V =]1 - 1.57] (563,063.30 ha)	mean	0.15	0.60	0.012	0.61
		no. patches x_V = 0	73,136	15,193	67,584	43,224
		% patches x_V = 0 $^{(*)}$	64.27	13.35	59.39	37.98
		total area x_V = 0 [ha]	271,474.10	21,355.85	448,720.03	328,386.09
		% area x_V = 0 $^{(**)}$	48.21	3.79	79.69	58.32
	3rd tertile: TOT_V =]1.57 - 3.53] (362,023.30 ha)	mean	0.24	0.86	0.019	0.96
		no. patches x_V = 0	40,890	868	64,398	2,338
		% patches x_V = 0 $^{(*)}$	43.43	0.92	68.41	2.48
		total area x_V = 0 [ha]	198,254.15	1,134.46	305,528.38	17,732.95
		% area x_V = 0 $^{(**)}$	54.76	0.31	84.39	4.90

x_V= (CONS_V, NAT_V, RECR_V, LANDS_V)
$^{(*)}$ percentage of patches with x_V=0 with respect to total number of patches in the corresponding tertile
$^{(**)}$ percentage of areas with x_V=0 with respect to total area included in the corresponding tertile

Tab. 1 Mean value, number of patches taking the null value and their percentage with respect to the total number of patches in the corresponding tertile, total area of patches taking null values and their percentage with respect to the total area included in the corresponding tertile for each macro-category, for each tertile and for each of the four values

In addition, although the highest percentages of areas taking null values correspond to RECR_V (95.34%; 82.98%; 71.26% between the first and the third tertiles), the maximum value pertains to LANDS_V (98.88% in the first tertile). Still looking at the percentages of areas taking null values, CONS_V has a very high value in the first tertile, and moderate and similar values in the second and third tertiles. In relation to unprotected areas, the mean and the percentage of patches taking null values show an opposite trend. For each x_V, the former always increases and the latter gradually decreases (except for RECR_V), when switching from the first to the second and third tertiles. As for the percentage of patches taking null values, although the highest values correspond to RECR_V (78.25%, 59.39% and 68.41% in the first, second and third tertiles,

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

respectively) and to CONS_V (79.62%, 64.27% and 43.43% in the first, second and third tertiles, respectively), the most significant variation from the first to the third tertile pertains to LANDS_V, which decreases from 95.08% in the first tertile to 2.48 in the third. Still looking at the percentage of patches taking null values, the lowest values correspond to NAT_V (13.75%, 13.35% and 0.92% in the first, second and third tertiles, respectively). The percentage of areas taking null values shows a similar trend to that described for the percentage of patches, the only exception being CONS_VAL and RECR_V, which show a fluctuating trend when switching from the first to the second and third tertiles.

4 DISCUSSION AND CONCLUSIONS

The results of this study show rather high mean values in the third tertile of the total value and lower mean values with reference to the first and second tertiles for NAT_V, both in case of protected and unprotected areas. Moreover, as for NAT_V, the percentage of areas taking null values does not exceed 5% in both the two macro-categories. In order to strengthen the suitability of a patch to be included in the Sardinian regional GI, the outcomes related to NAT_V suggest two types of plan actions for both the two macro-categories. The first concerns patches taking non-null values, with particular attention to the first or to the second tertile. Its mean shows similar values in case of both protected and unprotected areas, ranging between 0.4 and 0.6. The rather low values of the mean suggest considerable scope for improvement. Two issues should be addressed within spatial policies: first, the mitigation and/or elimination of threats through the implementation of specific actions, such as soil restoration in sealed soils, regeneration of undergrowth and monitoring of pasture and grazing land; second, the mitigation of land-taking processes and of land cover transitions spurring qualitative degradation (Lai et al., 2017a, 2017b), since the quality of land cover is the main factor that influences NAT_V. In relation to CONS_V, for each of the tertiles, the mean takes significantly higher values in protected areas than in unprotected areas. Moreover, the quite low value of the mean as regards the first tertile reflects the high percentage of patches taking the null value, which exceeds 90% of the total area both in protected and unprotected areas. The percentage of areas taking null values is fairly lower as regards the second and third tertiles than in the first tertile both in protected and unprotected areas, even though in the second macro-category the percentage is twice as that in the first. As a consequence, extending the environmental protection regime concerning habitat and species beyond Natura 2000 sites can represent an effective policy recommendation to strengthen the suitability of patches to belong to the regional GI. In fact, in the study area, some Natura 2000 sites coincide with the other protected areas here analyzed (national and regional parks and Ramsar sites), where conservation measures related to Natura 2000 sites are already in force. This, taking also account that the size of protected areas is around a quarter of that of unprotected areas, suggests that policy and planning actions should focus on additional measures to maintain and protect habitats and species. In addition, extending conservation measures beyond the boundaries of the Natura 2000 sites requires, on the one hand, advancement of scientific knowledge concerning habitats and species outside the Natura 2000 sites, and, on the other hand, lobbying activities towards the national government and the European Union to enlarge the Natura 2000 Network. With regard to LANDS_V, the third tertile is characterized by the small total size of areas taking the null value whereas the first tertile shows an opposite situation both in case of protected and unprotected areas. Indeed, the area of patches taking null values constantly increases when switching from the third to the second and first tertiles in the two macro-categories, although in the second tertile the percentage of areas taking null values is comparatively higher in the case of protected areas. These data suggest that landscape assets are mainly located within unprotected areas. In order to strengthen the suitability of a

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

patch to be included in the Sardinian regional GI, planning actions should focus on the identification of landscape assets both in protected and unprotected areas, which requires a close cooperation in terms of co-planning procedures between local municipalities, the Sardinian regional administration and the national Ministry of cultural goods and activities, and of tourism. In fact, the status of protected landscape asset can be acquired as a result of the procedural process established in compliance with the Italian Code on cultural goods and landscape. As for RECR_V, all of the tertiles are characterized by high percentages of areas taking null-values (above 70%) both in protected and unprotected areas. However, unprotected and protected areas show an opposite trend when switching from the second to the third tertile. In fact, the share of areas taking the null value is higher in unprotected areas in relation to the second tertile and higher in protected areas as regards to the third tertile. With reference to the second tertile, a possible explanation concerns differences in the environmental protection regimes in force: since in unprotected areas access is not restricted, the probability of visitors posting images increases. In relation to the third tertile, the larger number of images posted can be justified by the attractiveness of protected areas. As a result, the outcomes of our study suggest no evidence of a correspondence between the suitability of patches to be part of the regional GI and recreational attractiveness in both protected and unprotected areas. On the other hand, as pointed out in a recent study (Cannas et al., 2018), attractiveness represents a factor that significantly influences the inclusion of patches in the Sardinian regional GI. Moreover, due to its volatile nature, recreational value requires further specific insights to be implemented in future research. In conclusion, the proposed methodology can be applied to other Italian and European regional contexts. Indeed, Natura 2000 sites are identified by all Member States under the provisions of the Habitats and Birds Directives, and, despite different national institutional frameworks, the other protection regimes can be easily compared across other European contexts.

NOTES

This paper is written within the Research Program "Natura 2000: Assessment of management plans and definition of ecological corridors as a complex network", funded by the Autonomous Region of Sardinia for the period 2015-2018, under the provisions of the Call for the presentation of "Projects related to fundamental or basic research" of the year 2013, implemented at the Department of Civil and Environmental Engineering and Architecture (DICAAR) of the University of Cagliari, Italy. Sabrina Lai, Federica Leone and Corrado Zoppi have made substantial contributions to the paper's conception, background and design remarks (section 1). The methodological discussion proposed in section 2 is by Federica Leone. Sabrina Lai took care of the database and results presented in section 3. The discussion and concluding remarks of section 4 are by Corrado Zoppi.

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ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5