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Land Use Change and Habitat Degradation: A Case Study from Tomar (Portugal)

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Abstract. From the beginning of the 21st century, following major global and European initiatives such as the Millennium Ecosystem Assessment (2005) and The Economics of Ecosystem and Biodiversity (2010), the idea that ecosystem services could be used as a decision support tool, gained considerable importance in several fields: from economy to public policy, from territorial planning to environmental assessment. Defined as the set of goods and services provided by ecosystems for the benefit of humans life quality, they express the potential to overcome traditional and not sufficiently effective approaches of policies and interventions undertaken so far for biodiversity conservation purposes. In urban and territorial planning disciplines, it is therefore necessary testing new tools capable of spatially explaining territorial components that constitute biodiversity hotspots or, specularly, threats to biological diversity persistence and resilience. Taking part to this methodological framework, this work assesses changes in habitat quality, considered as a proxy for biodiversity, in Tomar (Portugal), a study area particularly affected by forest fires-driven degradation phenomena. Results highlight the potential of such tools in explicating the role of different territorial threats on biodiversity conservation and points out the importance of proper natural and semi-natural environments' management.

Keywords: Ecosystem services · Habitat quality · Tomar (Portugal) · InVEST · Wild-fires

1 Introduction

Ecosystem services'issue (ES) has gained increasing consensus [1, 2] both on the importance of their assessment and on the integration of this approach into natural resources' management decisions and spatial planning. Since biodiversity is representative of ecosystems' and functional diversity, the greater it is, the greater are the benefits and the advantages for all organisms. Ecosystem components, processes and functions therefore constitute ES. Sharing the view that, while satisfying human needs,

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protecting habitat quality is a priority in ecosystems management, modelling biodiversity as a function of both anthropogenic and non-anthropogenic origin threats, is useful to support management and policy making system. This new approach allows to better design sustainable and environmental policies [3–5] and deeply understand the interaction among territorial components and relative processes and dynamics [6]. The purpose of this work is to test Habitat Quality InVEST (integrated valuation of ecosystem services and tradeoffs) [7] model in order to describe the spatial distribution of threats to biodiversity in the Tomar (Portugal) study area and to assess habitat degradation over a time period ranging from 2007 to 2015. As highlighted from many authors [8–12], this tool reveals to be useful in assessing the impact of changing in land use/land cover (LULC) or, equally, in appreciating benefits from conservation policies. In order to support decision and policy makers in analyzing time series, a further advantage is the possibility to model past and future scenarios [13].

This work presents the results of an application in the study area of Tomar (Portugal) where the role of fires in relation to changes in habitat degradation was investigated.

2 Study Area

Tomar is a Portuguese Municipality with slightly more than 40,000 inhabitants and an extension of about 350 km^2, located in the district of Santarém, in the Centro region, subregion Medio Tejo. It is a town on the banks of Nabão river with a historic centre, characterized by a network of narrow streets dominated by a castle-fortress of Templars Knights.

As can be seen from Fig. 1, the municipal territory is mainly wooded. Forests are to a large extent the result of policies from the twentieth century onwards, that have characterized changes in land use/land cover all over the Country.

Today, 97% of Portuguese woodland is privately owned, resulting very vulnerable to wild fires since the most common kind of trees is eucalyptus, the most easily flammable. This tree species, not autochthonous but imported from Australia since the 1970s, has quickly become the first by extension on national soil, to support the paper industry that was starting to grow more and more in those years [14]. Both large and small properties have been converted into monocultures of eucalyptus, which is the most profitable species due to the speed with which it grows (10 years or even less are enough to have new wood for cellulose extraction) and which is selected and cloned in nurseries, to then be planted.

For the recovery of burnt areas and to prevent major new fires, the government has earmarked funds for fuel charge reduction in areas at risk. Furthermore some non-governmental environmental organizations, have reforested some of the steep areas affected by the fires.

As can be seen, the study area is characterized by a low population density and a growth of buildings that has occurred mainly along the road network according to the classic dynamics of sprawl [15].

In rural areas [16], on the other hand, further away from the urban aggregate, settlement component assumes typical characteristics of sprinkling [17–20] with a very low building density (related real estate issues [21–24]) and an evolution difficult to predict as it is not linked to any existing infrastructure.

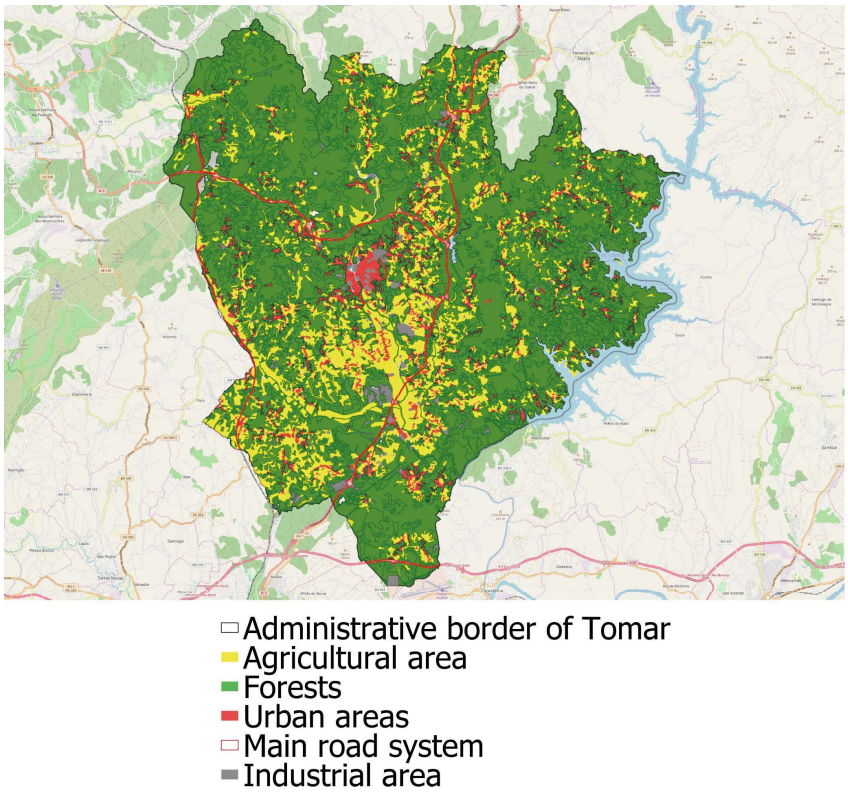

Fig. 1. Study area

3 Materials and Methods

The tool adopted to analyze how the intensity of human activity influences habitat degradation and to define the effects of ongoing threats is the Habitat Quality model [25, 26]. Belonging to the InVEST suite [7], it is based on the idea that higher HQ corresponds to higher richness of species and vice versa [27], providing as results two different maps: habitat quality and habitat degradation. Habitat degradation, in particular, is a function of the sensitivity of each LULC class to each of defined threat, of their relative weight and depending from the distance and the decay function for each of impact sources. Methodology and consideration about the values used are deeply described in previous works [28, 29].

Values used for running the model are summarized in Table 1 and Table 2.

To compute on-board effects, an area with a greater extent was considered by a buffer operation equal to 10 km, the maximum distance from the threat i-th considered.

For Tomar's land use map of 2007, 2010 and 2015, threats were classified into five categories: buildings, road infrastructure, agricultural areas, quarries and fire. These areas have indeed recorded in recent years an increasing number of fires, which constitute not an isolated problem, and which affect the risks of desertification caused by climate change.

Table 1. Threats summary table

Threat	Max_Dist	Weight	Decay
Residential areas	10	0.8	Exponential
Agricultural areas	8	0.5	Exponential
Fire	6	0.9	Linear
Pollution	4	0.5	Linear
Roads and railways	1	0.6	Exponential

Table 2. Habitat and sensitivity summary table

LULC	Habitat	Residential areas	Agricultural areas	Fire	Pollution	Roads and railways
Water bodies	1	0.8	0.4	0	0.8	0.7
Residential areas	0	0	0	0	0	0
Industrial areas	0	0	0	0	0	0
Roads and railways	0	0	0	0	0	0
Quarries	0	0	0	0	0	0
Urban green and gardens	0	0	0	0	0	0
Wind power	0	0	0	0	0	0
Vineyards and olive groves	1	0.6	0	0.8	0.8	0.7
Landfill sites	0	0	0	0	0	0
Orchards and citrus groves	1	0.6	0	0.8	0.8	0.7
Deciduous forest	1	1	0.6	0.9	0.9	0.9
Coniferous forest	1	1	0.6	0.9	0.9	0.9
Fallow field	1	0.6	0	0.8	0.8	0.7
Forest	1	1	0.6	0.9	0.9	0.9
Vegetable gardens	1	0.6	0	0.8	0.8	0.7
Arable land	1	0.6	0	0.8	0.8	0.7

4 Discussion and Conclusions

Degradation values resulting derives from the relationship with adjacent cells and for this reason, the results are expressed in relative terms with respect to present conditions, thus expressing a range from 0 to a maximum equal to 1. The results concerning the time period investigated are represented in Fig. 2.

Most of territorial transformations are not of anthropic origin, but rather linked to forest fires. As a threat to biodiversity, this source of impact has not a negligible intensity both because the tree species are characterized by high flammability, and because the high frequency of wild fires can contribute in the medium-long term to desertification processes. Furthermore, this threat is expected to increase because it is indirectly linked to climate changes.

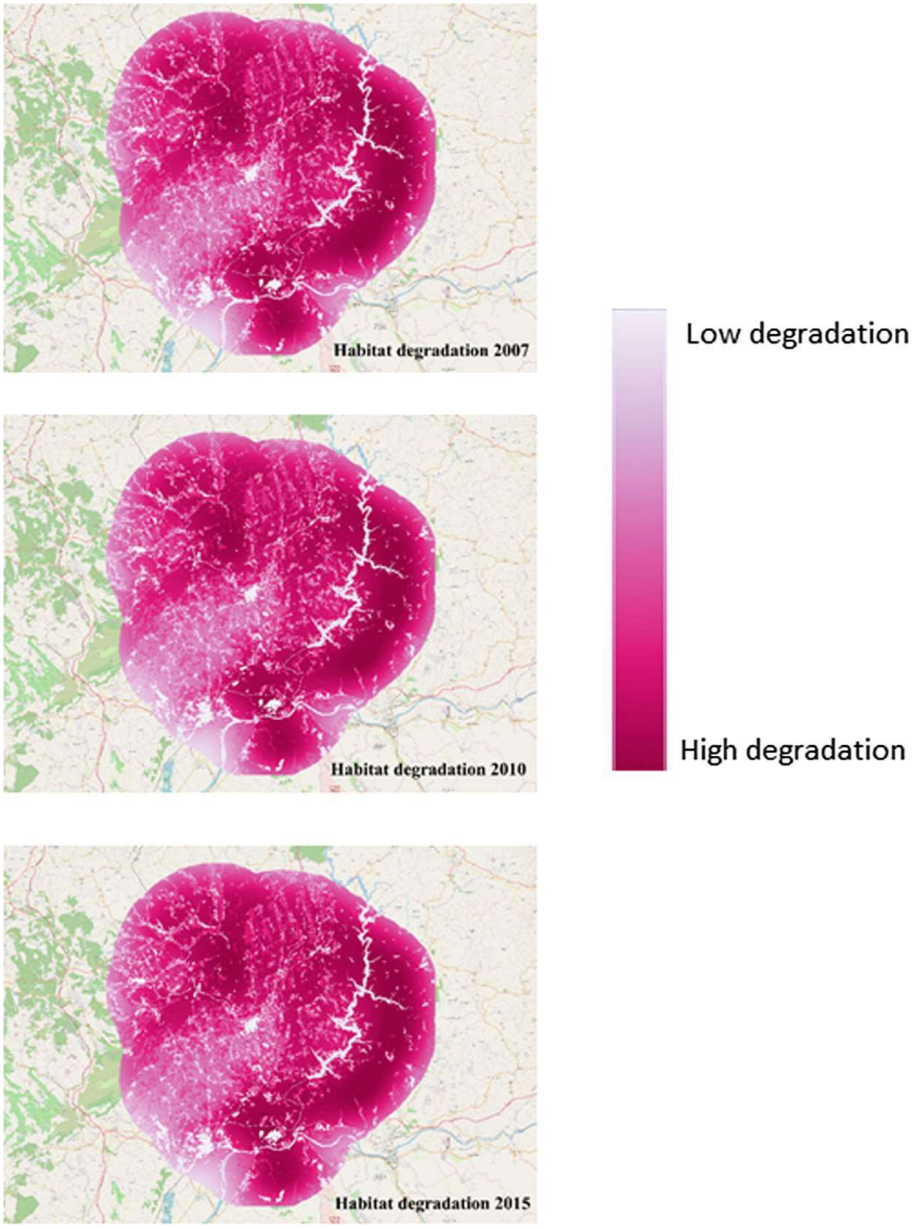

Fig. 2. Degradation maps for the study area over a time period ranging from 2007 to 2015

At the study area scale, changes in habitat degradation are not clearly visible. In order to highlight where alterations occurred, a difference between habitat degradation maps referred to 2015 and 2007 was calculated (see Fig. 3).

It shows a significant decrease in habitat quality occurred in wooded areas between residential settlements. This, therefore, highlights that most vulnerable areas are those where transition from residential to woodland are present, namely where the cumulative effect distribution due to several threats is higher. In order to assess the effectiveness of policies and intervention regarding biological diversity conservation, InVEST Habitat Quality and Degradation proved to be useful in the spatial identification of territorial areas where there is the greatest loss of ES provision. The approach provide a low-accuracy biodiversity proxy but it is useful to compare landswithout having data about flora and fauna populations within the context of the study area.

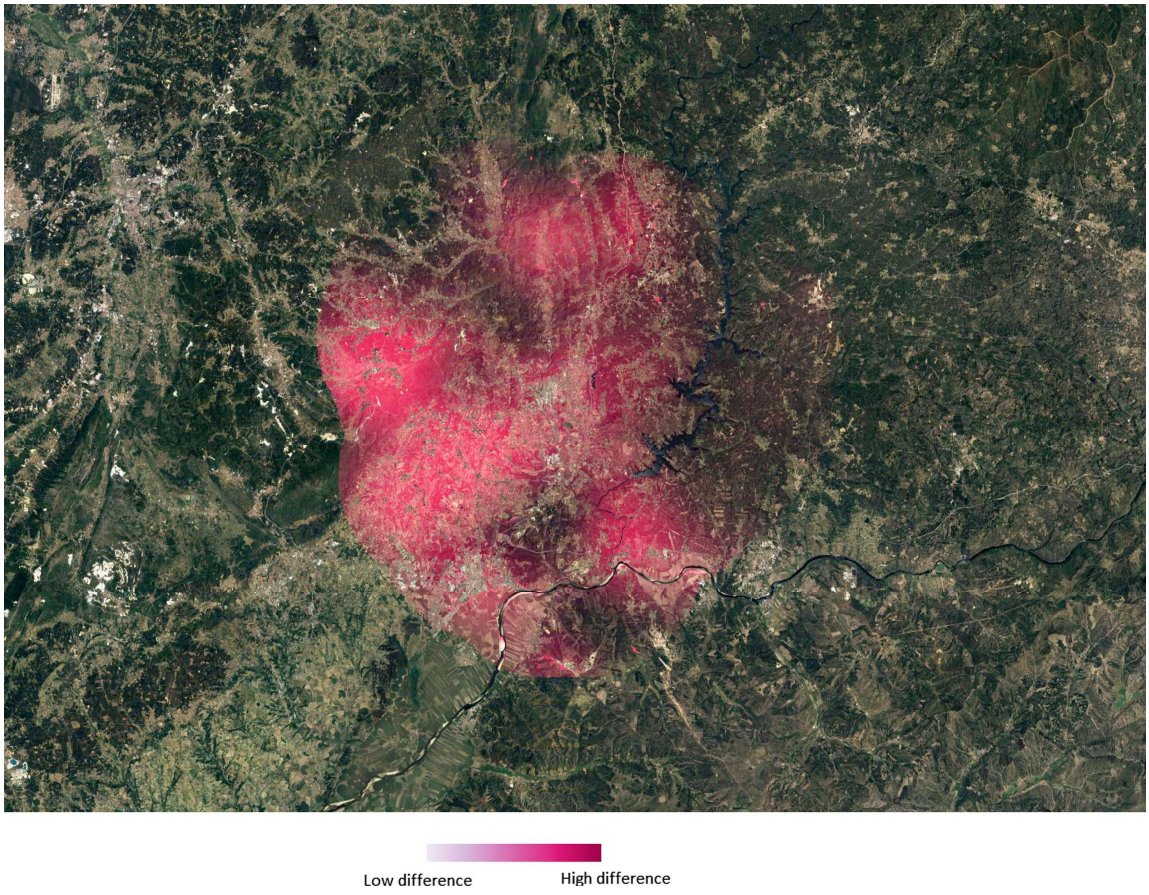

Fig. 3. Difference in habitat degradation between 2015 and 2007

Some limits and weaknesses of the model regard the accuracy of input data selection and the subjectivity in the attribution of sensitivity values. Regarding the interpretation of final results, it should be remarked that the linear overlapping of the effects linked to different threats, has the drawback of neglecting the interaction which (certainly not linear) between different impact sources which, acting simultaneously, can amplify each other's effects. On the other hand, however, this simplification allows

an easy management of such a complex assessment. As highlighted from the authors in previous works [28–31], this kind of spatially explicit evaluation have different advantages. It's possible to implement it at different planning scales [32, 33] providing appropriate information for a spatial planning and management system [34] which at the same time ensures, the reduction of land consumption [35] taking into account territorial features and their ecosystem functionality [36, 37]. A further advantage is the possibility of building alternative scenarios [38], present or future, in order to balance/compensate the effects of specific land use/transformation policies.

Our results while not demonstrating an objective value in the ability to determine impacts and spill-over on time [39], allow to identify areas in which to deepen with field investigations the study of the environmental components (flora, fauna, biodiversity, etc.) potentially degraded by land uses that have been considered as threats in the analysis [40, 41]. With an accurate input parameters calibration, this tool could reveal to be supporting for decision making processes and conservation policies' design and it may provide a synthetic support for the assessment of different kind of impacts both from natural and anthropic origins.

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